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INDEX

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Roads and Streets—1st Wednesday

(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday

(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday

(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday

(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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How Low Will Wages Fall?

Since 1913 wages have risen on the average about 80 per cent in America. Wholesale commodity prices in November averaged 107 per cent above the 1913 level. During our civil war wages rose but slightly, averaging in 1865 only 10 per cent above the level of 1860, whereas wholesale commodity prices rose 90 per cent during the same period. But in 1867 average wages had risen 10 per cent above the level of 1865, whereas commodity prices had fallen 24 per cent. Although commodity prices continued to fall after 1867 at the rate of about 4 per cent a year, wages continued to rise at the rate of 5 per cent yearly. In the year 1872 wages had risen to a level of 156 compared with 100 in 1860, or 56 per cent rise, whereas wholesale commodity prices had fallen to a level of 122, or 22% above the level of 1860. Then came the panic of 1873, the effect of which was very slight upon wholesale commodity prices but quite severe upon wages. By 1873 wages had fallen from the 156 level of 1872 to a level of 134, a drop of about 15%. During the same period wholesale commodity prices dropped to a level of 114, a decrease of only 7% during the four years of "hard times."

To anyone who is interested in the probable future of wage changes, the facts just given will be significant. It is being commonly said that because commodity prices are falling, wages must necessarily fall. Yet it is evident that no such thing happened during the seven years that followed the close of our Civil War. One reason for the great rise in wages immediately after the Civil War is to be found in the fact that wages had risen but slightly (10%) during the war, whereas commodity prices had risen enormously (90%). The revival of industry following the post-war depression, created a demand for labor that caused a rise in wages. Relative to the prices charged for commodities, workers were underpaid until 1870, when wages and commodity prices both stood at a level of 136, or 36% above the level of 1860, which was also the per capita increase in money in circulation.

Since wages in this country are now at a level of 180 compared with a level of 100 in 1913, whereas commodity prices are at a level of about 200, it is evident that commodity prices must fall another 10% before wages and commodity prices will again be on a parity. The per capita money in circulation is now about 70% in excess of the amount in 1913, and is likely to decrease relatively little in the next few years. For reasons given at great length in our issue of April 7, commodity prices always increase fully as much as per capita money increases; hence, one may look for an average price level of about 170 as compared with 100 in 1913. This will mean a further recession of about 15% from the present level, which will probably occur within the next three months. To descend to this "new plateau of prices," present average wages now would have to drop only 6%. Bear in mind that the great panic of 1873 caused a wage drop of only 15%, and that it took three years to effect that decrease.

In the textile and metal trades the rise in wages during our recent war greatly exceeded the average rise. Textile and steel workers secured increases that averaged about 120%. They will now probably suffer a decrease of about 20% to bring them back to the general level of wages. In fact, such decreases have already been accepted by some of the workers in those two trades.

The wages of railway employes are about 80% above the pre-war level, and freight rates have been increased about 75%. There is little likelihood that either railway wages or freight rates will be lowered for many years.

Skilled labor wages in the construction field now average less than 80% above the pre-war level, but common labor averages about 120% above the pre-war level. It is probable that common labor will have to accept a reduction of 20%, this spring, but that skilled labor will not be reduced more than 10%, if it is reduced at all.

Summing up, it is probable that a "new plateau of prices," about 70% above those of 1913, will soon be in effect, and that both wages and prices of materials will take this new level. Whether prices and wages recede further from this "plateau" will depend mainly upon whether our per capita money decreases and our average efficiency of production increases. Those two factors are likely to change but slowly. Their combined effect will probably not lower the price level more than 5% yearly.

A Chance for Engineers to Address Chambers of Commerce

[illegible] that [illegible] and [illegible] and [illegible] affect price levels and be prepared to demonstrate the cor- [illegible]

Beginning in our issue of Apr. 7 we have published a series of articles on "price levels," bond interest rates and wages, from which any engineer can secure enough data to make prognostication within narrow limits reasonably certain.

The editor has addressed several chambers of commerce on the topic of price levels, and has found that business men are not only keenly interested in the subject but densely ignorant of the causes of changes in price levels. If in every city some engineer would undertake to deliver a course of, say, three lectures on commodity prices, wages and interest rates, a long step would be taken toward convincing the public that engineers are not merely engineering economists but political economists. This alone would be helpful even if no other result were immediately secured. But the editor believes that in many communities the business men would decide that the time is at hand to resume "business as usual."

For such a lecture, a few large charts should be prepared to show average wages, commodity prices, and bond interest yields for each of the past 60 years. The editor has also used a chart (enlarged from that given in our issue of Apr. 7) showing the steady rise in per capita productivity in America from 1869 to 1909, and the subsequent stationary productivity. This "curve" of productivity overlaps the "curve" of average "real wages," showing that, contrary to the claims of many workers, the average worker has received increases in "real wages" exactly proportional to the increases in average per capita productivity.

It should be explained to an audience, that "real wages" for any year can be calculated by dividing "money wages" by the wholesale commodity index price of that year. Few business men know what an "index price" is, or that the Bureau of Labor publishes such prices in its monthly magazine. But the usefulness of such a standard is readily explained.

There is no subject of greater interest today than the subject of price and wage changes; hence an audience of business men can be easily secured for any speaker who professes to have studied the subject.

Sophistical Arguments in Favor of Increasing the Gold Supply

The two leading mining journals persist in urging the [illegible]ty of increasing the world's stock of gold, in spite of [illegible] t the world is already surfeited with money. The [illegible]

[illegible] mists, including several [illegible] vastly [illegible]

Here is an excellent example of the "straw man" species of argument, for the fact is that no modern economist claims that commodity prices are inversely proportional to the quantity of gold. On the contrary, it is held that the entire volume of money (whether paper, silver or gold) affects commodity prices; so that when the editor of the Engineering and Mining Journal cites prices in Austria and Germany in proof of the fact that paper money inflation has increased prices, he fails to shake the existing theory. He adds:

> [illegible] ning factor as regards the relation between [illegible] ch price is evident, and was pointed out in a [illegible] It is true that abundant money produces high [illegible] ities but in the world today the whole world [illegible] eap money is mainly paper. Prices of com- [illegible] to decrease as the ratio of paper to gold reserve or "cover" decreases; and this can be accomplished by reducing the paper, or increasing the underlying gold security, or both. The most expeditious way is to do both; in fact, for countries like France and Italy, which are in a desperate condition of inflation, [illegible] is imperative, and is being eagerly sought by the countries in question.

The second sentence of the last quotation is true, but the third is not. It has never been shown that the "ratio of paper to gold reserve" is a factor that affects commodity prices, except in extreme cases where confidence in the paper money has almost, if not completely, vanished. In America there is perfect confidence in the soundness of our currency, and commodity prices are high not merely because the stock of gold has increased 50% since 1913, but, primarily, because our entire money in circulation is 70% greater per capita than in 1913. Our political problem consists not in increasing our gold reserves, which are ample, but in decreasing our total currency. It might be wise gradually to ship back to Europe the billion dollars of gold that Europe shipped to us during the war, and coincidently to reduce our paper currency. Of the eleven billion dollars that our allies owed us, only one billion has been paid to us, and that payment has proved to be a curse, because it greatly inflated our currency and thus increased commodity prices. If we were to return the billion dollars worth of gold to our allies and then accept eleven billion dollars worth of long term bonds for their entire debt, we would not only reduce our present price level to the pre-war level, but we would hasten the restoration of normal exchange rates with our allies. This also would bring about the resumption of gold mining in America; for all that is needed to accomplish that is the restoration of pre-war prices.

There is little likelihood that such a plan will be adopted, because our national legislature is composed, mainly, of men who are not trained to solve economic problems.

Proportioning Concrete Aggregates When Unscreened or Pit Run Gravel Is Used

To the Editor: The article in your Dec. 1, 1920, issue, "Proportioning Concrete Aggregates When Unscreened or Pit Run Gravel Is Used," is well worked out for convenience in determining the quantity of cement required to insure the same sand-cement ratio, but the application of the method to actual production of concrete in the field is an entirely different matter.

As the author says, specifications usually state definite arbitrary proportions which are to be used, but the aim in any case is to aid in producing a concrete which will have some definite strength. While not usually justified by test data, specifications generally associate a 1:2:4 proportion with a concrete which it is hoped will attain a strength of 2,000 lb. at 28 days. Incidentally lack of field tests is responsible for its remaining nothing but a hope and often failing to become a reality. Presumably the method outlined in the article is intended to result in concretes of definite or equal qualities when more than the usual proportion of sand is present, although this strength relation is not definitely stated.

As a basis of the outlined scheme, the assumption is apparently made, unsupported by test data, that concretes of equal strength will be obtained, so long as the cement-fine aggregate ratio is a constant. For example, from Table 1, where the percentage is .33 approximately 4.8 bags of cement are required for a 1:2:4 concrete, while in case all of the pit run material is classed as sand, 14.5 bags of cement are required. No tests should be needed to demonstrate the absurdity of such relations for concretes of equal strength. For equal flowabilities a mortar of 14.5 bags of cement and 1 yd. of sand may be as much as 100 per cent stronger than a 1:2:4 concrete in which only 4.8 bags of cement are used per yard of aggregate.

Such a scheme as advocated for the use of pit-run materials only adds to the weight of evidence which discredits the method in common use of arbitrarily specifying concrete proportions. As a labor saving device in computing quantities these tables insure definite volume relations for the materials before mixing water is added, but instead of assuring concretes of equal strengths, as seems to be erroneously assumed, they will result in concretes differing widely in strength. If a concrete having the usual 2:4 sand gravel relation will have the required designed strength, the high sanded aggregates will have excess strengths varying directly, but not necessarily proportionally, with the sand content.

More attention to the testing of concrete as it is actually made and placed in the work will assist in emphasizing the fact that very often the strengths obtained in practice fall considerably short of the ultimate strength values used in design. Until this fact can be impressed upon engineers and designers, little progress will be made in the elimination of arbitrary proportions from specifications.

To efficiently use pit run materials on smaller jobs where the quantities needed do not warrant the separation into sand and gravel a method outlined in detail by R. W. Crum in the 1919 proceedings of the American Society for Testing Materials and later reprinted in Engineering and Contracting of July 2, 1919, has been found accurate so far as tested. This method of proportioning is properly based on a decrease of the cement-sand ratio as the percentage of sand in pit run aggregate increases and will result in concretes of approximately constant or equal strengths.

To insure concretes equal in quality to those considered in design, definite minimum strength values should be specified and checked during the progress of the work by systematic testing of the concrete as placed. On work of any considerable size, better control and a more uniform product will result from the use of sand and gravel rather than pit run material. A short series of tests will determine the most satisfactory sand-coarse aggregate ratio, and additional tests of concretes using the predetermined aggregate ratio with various proportions of cement for the ranges of flowabilities commonly used in practice will permit of definite conclusions as to the cement content needed for any necessary flowability and specified strength. Allowances must be made for the greater variations in quality of field concretes due to unavoidable variations from batch to batch in proportions, water content and quality of cement itself from time to time. For given aggregates a definite strength requirement alone is all that need be contained in the specification together with the outlined scheme for sampling and testing, but a series of tests as described above, after once being made, will be of great assistance in estimating in advance the quantities of cement required.

The diagrams presented by Mr. Doan involve only volume relations of cement, fine aggregate and coarse aggregate to insure concretes which before mixing water is added, have constant cement-fine aggregate ratios. Mathematically the curves are correct and prove the authenticity of the equations, which are included, but practically they offer no assistance in proportioning aggregates so as to obtain concretes of equal strengths on the job.

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University of Saskatchewan.

Saskatoon, Canada.

Iowa Engineering Society Annual Meeting.—The annual meeting of the Iowa Engineering Society will be held at the Chamberlain Hotel in Des Moines on Jan. 18-19 and 20. Every indication points toward a very successful meeting. A feature of the occasion outside of the usual technical and social program will be the manufacturers' exhibits. Special attention is being given to the planning of these exhibits with a view toward making them interesting and profitable. There are now approximately 1200 registered engineers in the State of Iowa. This fact coupled with the fact that the state legislature meets in Des Moines in January is arousing unusual interest in this meeting. Lloyd A. Canfield, 406 Flynn Bldg., Des Moines, Ia., is chairman publicity committee.

Voidage and Weight of Broken Limestone

The U. S. Bureau of Standards has compiled a paper on the weight per cubic foot of broken limestone and its dependence upon the specific gravity of the solid material and the percentage of voids. The paper, which is reprinted below, also gives the voidage of various kinds of loose materials, such as sand, gravel and stone.

The weight of a cubic foot of limestone, or any similar material, depends primarily upon two factors:

1. The percentage of vacant spaces or "voids" between the particles. This varies with the amount of packing or ramming, moisture content, solid impurities, shape of the particles, and relative size including uniformity of size or mixture of miscellaneous sizes.

2. Specific gravity of the individual particles of the material. This varies considerably with locality.

Voidage.—Frye's Civil Engineers' Pocket Book, p. 416, states:

> The voids in sand amount generally to about 33 or 34 per cent of the gross bulk; in gravel, to about the same; in broken sandstone, to about 40 to 42 per cent; in broken trap (diabase or basalt), to about 45 to 56 per cent. Generally the percentage of voids is greater in the freshly broken, hard, flint-like rocks, with less in the softer rock, which leave the crusher with less-defined edges. With gravel, where the edges have worn away, the percentage of voids is the least, hence gravel is the most economical aggregate to use for concrete because less cement, or mortar, is required. For the same reason, basalt or trap is the most expensive, although far superior for many purposes.

The same handbook, on page 911, also gives the following values for the voidage (but which appear to be a little lower than the other values given herein):

Crushed limestone, sandstone and softer rocks, run of crusher ..30%
Limestone, crushed to fine grains, loose 35%

Trautwine's Civil Engineers' Pocket Book (p. 213) states that for "limestones and marbles quarried in irregular fragments, 1 cu. yd. solid makes about 1.9 cu. yd. perfectly loose; or about 1¾ cu. yd. piled. In this last case 0.571 of the pile is solid; and the remaining 0.429 part of it is voids."

Merriman's Civil Engineers' Handbook (4th edition, p 501) states:

> Voids in coarse aggregates will range from 30 to 55 per cent depending upon the uniformity of the stone, its shape and degree of compactness. Voids in loose broken stone, crusher-run, with the fine material screened out, will generally measure from 43 to 48 per cent. If well shaken or rammed, as in the placing of concrete, thus reducing the voids to from 37 to 42 per cent, respectively. Stone screened to a uniform size will contain from 50 to 55 per cent of voids. Gravel of the same size as broken stone will contain less voids, as it packs more readily. With the sand screened out it will generally contain from 35 to 40 per cent voids.

Merriman also quotes (p. 501) results of I. O. Baker from Bul. No. 23, University of Ill. Eng. Exp. Sta., 1908, as to the voids in loose limestone from three localities; the voidage was determined by two methods, viz., first, by pouring in water; second, by weighings and use of specific gravity of solid stone. Mr. Baker's results are:

Locality.	Size of stone.	Per cent of voids. Pouring water.	Per cent of voids. Specific gravity.
Chester	⅜ in. screenings	40.9	46.8
Chester	¾ in. screenings	43.0	45.6
Chester	2 in. to ¾ in.	46.6	46.6
Chester	3 in. to 2 in.	46.1	45.1
Joliet	½ in. screenings	42.2	47.1
Joliet	2 in. to ½ in.	47.9	46.2
Joliet	3 in. to 2 in.	47.5	46.1
Kankakee	⅜ in. screenings	39.6	46.1
Kankakee	1¼ in. to ⅜ in.	45.7	44.7
Kankakee	2¼ in. to ⅜ in.	44.3	42.9
Kankakee	2¼ in. to 1¼ in.	46.2	43.4

The work of five other authorities is also quoted by Merriman (p. 501) and is summarized as follows:

Voidage for gravel, 3 values 34.1 to 36.5 per cent; Green River limestone, 2½ in. and smaller, dust screened out, 1 value of 48 per cent; sandstone, 2 values of 43.3 and 45.3 per cent; trap, 6 values 45.0 to 54.5 per cent.

Density of Solid Stone.—The density or weight per cubic foot of the solid material varies considerably with the locality. The values given in the following table are taken from various handbooks as follows: Frye's Civil Engineers' Pocket Book (2nd edition), Kidder's Architects' and Builders' Pocket Book (16th edition), Haswell's Mechanics' and Engineers' Pocket Book (57th edition), Trautwine's Civil Engineers'

[illegible]

[illegible]

[illegible]	Quotation [illegible]	[illegible]	[illegible] voidage. 47.5%.
[illegible]			
[illegible]	[illegible]	[illegible]	76.0
[illegible]	166.7	95.9	[illegible]
[illegible]	[illegible]	96.9	[illegible]
[illegible]	[illegible]	[illegible]	83.9
[illegible]	[illegible]	92.6	81.9
[illegible]	[illegible]	92.2	84.2
[illegible]	[illegible]	89.0	81.3
[illegible]	[illegible]	[illegible]	82.3
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	91.2	83.3
[illegible]	[illegible]	90.8	82.9
[illegible]	[illegible]	99.1	90.4
[illegible]	[illegible]	95.9	87.5
[illegible]	[illegible]	97.3	88.8
[illegible]	[illegible]	97.3	[illegible]
[illegible]	169.2	97.3	88.8
[illegible]	167.9	96.5	88.1
[illegible] plain	171.7	98.7	90.1
[illegible] say"	162.5	[illegible]	85.3
[illegible]			
[illegible]	[illegible]	83.3	73.0
[illegible]	[illegible]	96.3	87.9
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	81.8
[illegible]	[illegible]	[illegible]	86.9
[illegible]	[illegible]	[illegible]	79.8
[illegible]	[illegible]	97.2	88.7
[illegible]	[illegible]	93.2	85.1
[illegible]			
[illegible]	[illegible]	68.3	62.4
[illegible]	111.3	81.3	74.2
[illegible]	[illegible]	[illegible]	87.6
[illegible]	[illegible]	91.3	83.3
[illegible]	[illegible]	86.0	79.0
[illegible]	[illegible]	99.9	91.2
[illegible]	[illegible]	[illegible]	82.0
[illegible]	[illegible]	84.1	76.7
[illegible]	[illegible]	96.5	[illegible]
[illegible], blue	165.0	95.0	87.0
[illegible]	164.7	94.7	86.5
[illegible]	[illegible]	97.0	[illegible]
[illegible]	168.1	96.7	88.2
[illegible]	[illegible]	98.8	90.2
[illegible]			
[illegible]	[illegible]	114.3	104.3
[illegible]	[illegible]	113.4	103.5
[illegible]			
[illegible]	[illegible]	86.0	[illegible]
[illegible]	178.8	103.0	94.0
[illegible]	[illegible]	97.0	88.0
[illegible]			
[illegible]	125.0	72.0	[illegible]
to"	178.0	102.0	[illegible]

Weight of Loose Stone.—From the preceding quotations, a [illegible] to the [illegible] of the stone under [illegible] per cubic foot) [illegible] can be obtained from the following table the weight per cubic foot of the loose stone for the corresponding values of voidage and weight per cubic foot of solid material. The table also includes the specific gravity of the material, and the relative [illegible] the volume had been, if the loose stone had been obtained by breaking up the proper quantity of solid stone. For example,* if a [illegible] lb. per cubic foot (solid), its weight when broken with voidage of [illegible] per cent is 93 lb. per cubic foot, and its volume is 1.818 [illegible]

[illegible]

[illegible]	[illegible]	[illegible]	171.8	181.0 stone).
[illegible]	[illegible]	2.7	[illegible]	2.9
[illegible]	[illegible]	110	111	118
[illegible]	[illegible]	[illegible]	109	113
[illegible]	[illegible]	101	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	104
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Resurfacing Road Without Detouring or Obstructing Traffic

An interesting method of resurfacing a road without detouring or obstructing traffic was used by H. S. Perry, Maintenance Engineer of the State Highway Department of Ohio, in the reconstruction of the Logan-Athens road in Hocking County, Ohio.

The highway is the only connecting link between Logan, the county seat, and Athens, a coal mining town. It carries an unusually heavy traffic, the entire coal supply for Logan being transported over the roads in trucks and wagons. The hilly character of the country not only precluded a detour but made it impossible to turn traffic off to the side of the wearing surface.

Rolling 200 Ft. Strip of Rock Asphalt Surfacing on Logan-Athens Road, Hocking County.

Originally the Logan-Athens road was surfaced with gravel. About two years ago 2 in. of compacted stone was added and the surface treated with tar. This construction would not carry the heavy traffic, however, and last year (1920) a 2-in. wearing surface of Kentucky rock asphalt was applied. First, the wearing surface was widened 4 ft.; the old surface was 14 ft. Eight inches of compacted slag was used as a base in the new construction. Voids were filled with screenings to within a short distance of the top and the entire mass was waterbound. The voids near the top were left open to afford better anchorage for the asphalt surface.

[illegible] Asphalt Surfacing on Logan-Athens Road, Hocking County, Ohio.

The old surface was carefully swept with wire hand brooms. Depressions in the old macadam were filled with fresh stone and tamped. A paint coat was then applied and the road was surfaced with Kentucky rock asphalt.

The Kentucky rock asphalt was applied cold and raked to a depth of 3 in. First one side of the road was surfaced for a distance of 200 ft. and then the traffic was turned over the fresh asphalt surface, while the asphalt was spread on the other side of the road. Usually the asphalt had but one rolling before being thrown open to the heavily laden trucks and steel tired wagons.

In spite of the many difficulties and annoyances during construction, the finished asphalt surface is remarkably smooth. At periods during the day the traffic was so heavy that the workmen had to be on the alert to avoid being struck by the trucks and rapidly moving pleasure cars.

The Kentucky rock asphalt bonded perfectly where it was joined in the center of the road and after one day's traffic it was impossible to distinguish the joint. The work was done by the Maintenance Department of the state and was under the supervision of Emerson Graham, Inspector, and Rush Wolf, foreman. The only equipment was a 10-ton 3-wheel roller, rakes and shovels.

Cost of Repairing Asphalt Pavement of Los Angeles

The repairing of all asphalt and other bituminous pavements and macadam, in Los Angeles, Calif., except the replacing of excavations, is in charge of the Department of Maintenance of Paved Streets, a branch of the City Engineer's office. The following particulars of the work the department for the year ended June 30, last, are abstracted from the annual report of John A. Griffin, City Engineer:

During the year the force, which consists of one superintendent, three foremen, five enginemen, fourteen asphalt workers, twenty-seven laborers, nine 5-ton dump trucks and one 2-ton dump truck, was divided into three gangs, (part of the time into four gangs) one with Lutz surface heaters, one in San Fernando Valley on cover work, and the others on patch and reconstruction work.

The maintenance of paved streets is carried on by three methods, viz.: Lutz heater resurfacing, cover work process, and patchwork. With the Lutz surface heaters, two machines were operated, but seven months of this year, on account of a lack of finances. The city is in possession of four of these machines, which should be kept in operation the entire year, as many streets are in need of resurfacing. The work is performed by heating and removing a sufficient depth to allow addition of at least one in. of new finished surface, thereby saving two-thirds of the old asphalt layer, using it as a binder course. During the past year these machines were used on both sheet asphalt and warrenite with equal success. A great amount of work is carried on in this department by the cover process, which method was initiated by this department. Repairing by this method is done by spraying the section to be repaired with liquid asphalt, adding the new mixture on the surface of the old pavement, burning the joints with a hot smoother and rolling with either a gas or a steam roller. This work has been very effective and is done at less cost per unit of surface repaired than by the patch work process, which is to cut out worn areas and re-fill with new mixture.

The following table indicates the area of each class of work placed, and the cost per square foot:

	Per sq. ft.
Repairing by patch work 273,957 sq. ft.	$0.0860
Repairing by cover work 1,237,701 sq. ft.	.0557
Resurfacing part of Sherman Way, two layers, 75,957 sq. ft.	.1051
Resurfacing by heater work 799,470 sq. ft.	.0711
Surfacing bridges, 41,100 sq. ft.	.0892

The following material was supplied by the municipal asphalt plant:

	Cost.
21,010 cu. ft. of bituminous base and binder mixture	$ 3,230
164,870 cu. ft. of surface mixture	32,361
33,150 cu. ft. of Warrenite mixture	6,983
141,590 cu. ft. of Topeka mixture	24,890

L. Miller is superintendent maintenance of paved streets.

"Super-elevation and Widening of Curves on Minnesota State Highways."—In the article with the above title in our Dec. 1 issue the captions of the cuts were transposed. Figure 1 should be changed to Fig. 2, and should read as follows: "Figure 2—Plan and Section of Pavement at Curves, Showing Ring Method of Widening." Figure 2 should be changed to Fig. 1, and should read as follows: "Figure 1—Plan and Section of Pavement at Curves, Showing Lune Method of Widening."

Federal Aid Road Work in 1919-20

During the fiscal year ended June 30, 1920, a total of 1,670 Federal Aid project statements submitted by the states were approved by the U. S. Bureau of Public Roads, as compared with 1,310 projects approved from 1916 up to the beginning of the last fiscal year. The projects approved involve 16,673 miles of road, as compared with the 12,720 miles which had been previously approved; and the Federal Aid requisite on these roads amounted to $109,830,366, which was more than twice as great as the total amount of $54,714,219 requested during the three years 1917, 1918 and 1919. The above facts are taken from the annual report of Thos. H. MacDonald, Chief of Bureau of Public Roads, covering the fiscal year ended June 30 last. The report was made public on Dec. 14. An abstract of it follows:

Labor and Material Conditions During the Year.—During the fiscal year 1920 the execution of all classes of construction work has been greatly delayed by the most disadvantageous economic conditions which this country has faced in many decades.

Railroad congestion, strikes, and labor and material shortages, resulting in high prices of these essentials of construction, have combined throughout the country to delay work which had been undertaken, and to discourage the undertaking of any but the most important new projects. The high prices of labor and material have sent construction costs skyward, and the work which has been launched in spite of conditions has necessarily been curtailed to the limit of the funds available.

Highway construction has perhaps been more adversely affected than any other class of work. After the war there was a great public demand for the improvement of roads, which had been seriously damaged in many instances by the augmented traffic incident to the prosecution of the war. It appeared that the release of labor from war activities and the return of men from the military service would provide an abundance of labor. Indeed, it was thought, for a time, that highway work should be increased to provide employment for returned soldiers, if not for no other reason. Highway programs were accordingly greatly expanded, and in accomplishing this result the appropriation by Congress of the additional sum of $200,000,000 for Federal Aid in February, 1919, played an important part.

The army of laborers which was expected to apply for the work did not materialize. On the contrary, there has been at all times a distinct shortage of labor to carry out the work planned, and wages during the past fiscal year have reached the highest levels attained in the history of the country. Whereas, in 1917, competent labor could be secured in various parts of the country for from $1.50 to $3 per day, the corresponding wages this fiscal year were from $3 to $5 for a shorter day's work.

In proportion to the demand there was also a pronounced scarcity of the materials of construction. Sand, gravel, stone, and cement, materials commonly used in road work, increased in price between 1917 and 1920 by from 50 to 100 per cent. Naturally, these increases in the costs of the essentials of construction have been reflected in the prices paid to contractors for road work. A comparison of the costs of several of the common types of roadways in the fiscal years 1917 and 1920, shows an average increase in the cost of earth roads from $2,160 to $4,100 per mile; sand-clay roads which in 1917 cost $2,460 per mile on the average, this year have cost $4,685. Gravel roads have increased from $4,535 to $7,250 per mile; concrete from a cost of $21,165 to upwards of $40,000 per mile; and a brick road which now costs $55,000 per mile could have been built in 1917 for $33,000.

In view of the fact that the funds available for road construction are largely limited by statute or by the returns from taxation, and on account of the high prices prevailing, a majority of the states this year have deliberately withheld work, the plans for which have been completed, until such time as they could obtain a greater return upon the expenditure.

No small part of the reason for the high contract prices is attributable to the uncertainty of rail deliveries of material. Contractors who have been induced to enter the highway field in larger numbers than ever before, and who have invested large capital in plant and equipment designed to expedite construction, have lost heavily by reason of the failure of the railroads to make deliveries of material in accordance [illegible] their [illegible] their [illegible] ies [illegible]

[illegible] reau [illegible] deral [illegible] of [illegible] ly [illegible] con- [illegible] travel regularly, there were 108 which were held up by failure to [illegible] projects were getting prompt deliveries of cement, there were 172 [illegible] of this important material on time.

[illegible] stood [illegible] work got under way car shortages developed here and there almost continuously, and several times during the season this condition was general. Road work was very seriously hampered, and many projects which could easily have been completed had materials been available were carried over to the 1920 construction season solely because of the delays incident to inadequate rail transportation service. In our endeavor to secure the maximum service from the available equipment, [illegible] work under way as possible, close contact has been maintained with the Public Service Division and Car Service Section of the United States Railroad Administration. Much has been accomplished through this co-operation.

With a view to making use of the open-top cars which ordinarily stand idle during the early spring months, the state highway departments were advised to let construction contracts early, and contractors were urged to make early shipments, storing the materials for future use. This effort undoubtedly contributed to the fact that in the spring of 1920 there was little if any surplus of open-top car equipment, whereas in the spring of 1919 upwards of 250,000 open-top cars stood idle for a number of weeks.

With the return of the railroads to private control co-operative relations were established with the Interstate Commerce Commission and the Car Service Division of the American Railroad Association, in order to continue the work which had been carried on with the Railroad Administration. Everything possible has been done to assist the state highway departments in meeting their rail transportation difficulties. It is apparent that for several years the transportation of road building materials is going to be the limiting factor in our highway improvement program. It is imperative that the maximum possible service be secured from the available equipment. To accomplish this result the co-operation of the shipper, the contractor, the state highway departments, the Interstate Commerce Commission, the railroads, and this bureau is necessary. The bureau is shaping its organization so that it will be possible in the future to render greater service in this connection than it has been able to in the past.

[illegible] Administration to Expedite Work. The administrative work connected with the approval of plans, specifications, and estimates, and the checking and passage of vouchers for Federal Aid work performed became so great during the year that every effort had to be made to devise and adopt administrative methods calculated to facili- [illegible]

[illegible] of the year several administrative ar- [illegible] the operation of the law and made possible a degree of harmony in co-operation and an amount of completed work not [illegible]

[illegible] tion of [illegible]

[illegible] 11, 12 and 13 for the purpose of improving the administration of the act.

5. Arrangements have been made for the use of preliminary construction surveys covering heavy items of construction which [illegible] by the bureau before complete plans for the details of the work are prepared. This arrangement enables the state to begin construction at an earlier date than would otherwise [illegible]

6. After consultation with the Solicitor of Agriculture, it has [illegible] in many cases to draft project agreements and submit them to the state already signed by the Secretary of Agriculture. This makes it unnecessary to return the papers to Washington for s'gnature, and was done to enable the states to submit claims and receive payments of Federal aid promptly.

7. A separate division of the engineering force in the Washington office was organied to handle the Federal-aid vouchers submitted. [illegible] some months rises as high as [illegible], and each one of them involves the usual monthly estimate of construction, often very long and requiring the most careful checking and scrutiny. Large possibilities of delay existed in doing this work, and every effort has been made to expedite it.

8. By an understanding with the states, claims for Federal [illegible] for amounts less than $1,000. By this arrangement the number of vouchers has been reduced about 30 per cent below what they otherwise would be and the work of handling vouchers proportionately expedited.

9. Owing to the large number of incorrect claims for very small amounts, numerical errors in the pro rata and other purely technical details in vouchers which would ordinarily necessitate the return of the voucher to the state for correction, the practice has been adopted of using the 5 per cent retent uniformly made against the states to cover as many of these defects as possible.

Federal Aid Progress.—In spite of the untoward economic conditions, and attributable in no small degree to the improvements in methods of administration effected during the year, the amount of Federal Aid business handled, as represented by numbers of projects, was approximately 25 per cent greater during the single year than all previous work done under the act since 1916. An average of 139 new projects were received and approved monthly.

The amount of the appropriations made by the Congress which became available at the beginning of the fiscal year was $95,000,000, $20,000,000 of which was derived from the act of July 11, 1916, and $75,000,000 from the Post Office appropriation act of February 28, 1919 (H. R. 13308). From this there was deducted the 3 per cent allowed by law for administrative purposes, and the remainder, or $92,150,000, was apportioned among the several states. This amount was in addition to the $77,600,000 previously apportioned for the fiscal years 1917 to 1919, inclusive, so that the total amount which has been apportioned up to and including this fiscal year is $169,750,000.

Agreements with state highway departments were executed during the fiscal year to cover 1,286 projects, almost three times the largest number executed previously in any one fiscal year, and nearly twice the total number executed prior to the beginning of the year. The estimated cost of the projects covered by these agreements amounted to $197,571,626, of which amount there was set aside in the Treasury $85,906,556 as Federal Aid. At the close of the fiscal year 1919 there had been executed 677 of such agreements, involving an estimated cost of $56,418,763 and an allowance of Federal Aid amounting to $23,931,618. Thus, at the close of the fiscal year 1920 a total of 1,963 had been executed to cover projects involving 15,178 miles, at a total estimated cost of $253,990,389, including $109,838,174 of Federal Aid. Of the funds apportioned, therefore, there remained at the end of the fiscal year an unallotted balance of $59,911,826.

Under the terms of the Federal Aid road act the apportionments to the states for each fiscal year remain available for expenditure until the close of the succeeding fiscal year, but it is construed that funds covered by agreements are expended within the meaning of the law. Each state had a sufficient amount of funds under agreement at the close of the fiscal year to prevent its losing any part of the funds apportioned to it.

The fact that nearly $86,000,000 of Federal Aid was allotted this year indicates that it is only necessary to maintain the present rate to assure the allotment of the entire unallotted balance of $156,911,826 before the end of the fiscal year 1922, which is the date on which the last of the appropriations will lapse.

At the end of the fiscal year there were 1,835 projects under construction, involving 14,940 miles and Federal Aid to the amount of $103,925,094. These projects were in various stages of completion. The Federal aid allotted for the completed work amounted to $31,174,732. Many of the projects were more than 90 per cent complete; the average project was 30 per cent complete, the work done on them being roughly equivalent to the work required to entirely complete 4,500 miles.

In addition to this work done on projects still under construction at the end of the year, there were 292 projects, involving 1,677 miles and $8,920,353 of Federal Aid, which had been entirely completed. Including the projects under construction and completed at the end of the year, there were 16,617 miles of Federal Aid road which had been placed under contract, a mileage which exceeded the aggregate length of the projects for which formal agreements had been executed by 1,439 miles. This condition results from the ruling of the Secretary of Agriculture, which permits projects to be placed under contract as soon as the plans, specifications, and estimates have been approved in order to expedite the work.

Including the Federal Aid allotted for completed portions of projects under construction and to projects entirely completed, the Federal money allotted for completed work up to the end of the year amounted to $40,095,085. At the end of the fiscal year 1919 the amount allotted for completed work was only $4,658,749, so that the Federal Aid allotted to work completed during the year was $35,436,336. These figures do not represent actual vouchers paid. They are compiled from the reports of the district engineers on completed work and represent the value of the finished work more accurately than the sum of the vouchers paid, because of the lag which exists between the completion of the work and the payment of Federal Aid. The total cost of the work completed during the year, including the amount paid by the states, was approximately $80,000,000.

The rate of expenditure is increasing rapidly from month to month as more and more of the projects which have passed through the preliminary stages go under construction. The expenditure of $80,000,000 for the year will be greatly exceeded next year, but even this rate goes far beyond the rate of expenditure in the construction of the Panama Canal. The performance of the Government in the construction of the canal has been regarded the world over as a record-breaking achievement in respect to the dispatch with which it was carried out. The cost of that work, however, was only $373,000,000, and ten years were required to complete it, the average rate of expenditure being therefore only $37,000,000 per year or less than half as great as the rate of expenditure on Federal Aid roads this year.

Comparing the magnitude of the Federal Aid program with the entire highway program of the United States, the significance of Federal Aid is indicated by the fact that the amount of Federal money allotted to projects actually under construction at the end of this fiscal year, namely, $103,925,094, was only slightly less than the total expenditure of $106,861,053 from state funds for highway construction during the calendar year 1919 as reported to this bureau by the states.* The estimated total cost of these projects was greater than the whole expenditure during 1919 by states and local governments.

Location and Character of Federal Aid Roads.—The Federal Aid road act as amended requires that any road to receive Federal aid must be a rural post road, defined as any public road a major portion of which is now used, or can be used, or forms a connecting link, not to exceed 10 miles in length of any road or roads now or hereafter used for the transportation of the United States mails.

In addition to seeing that the roads for which aid has been requested by the states comply with this statutory requirement, the bureau has also made an investigation in connection with each project submitted to ascertain that the road in question is of sufficient general importance to warrant the expenditure of Federal Aid funds in its construction.

The Federal Aid funds will not be expended entirely for so-called national roads. A large part of the money will be expended in improving the roads which radiate from market and shipping points into the surrounding agricultural country, the class of roads which in the last analysis are most closely identified with the development of the country.

In many of the states, particularly those of the East, which have highway departments of long standing, the majority of the trunk-line roads have already been improved. In these states Federal aid is given to assist in filling the gaps which remain in the trunk systems, and for the construction of the more important lateral roads. On the other hand, there is a decided tendency in the younger states of the West to utilize their apportionments of Federal Aid on trunk-line highways of national importance. As an indication of the extent to which this policy governs, there was at the end of the fiscal year a total of 8,620 miles of Federal Aid road which had been approved, and which constituted parts of the several transcontinental trails, such as the Lincoln Highway, the Bankhead Highway, the Dixie Highway, the Jackson Highway, and others. This mileage represented 30 per cent of the aggregate length of all Federal Aid roads approved, and $58,745,359, or 36 per cent, of all the Federal Aid approved. Eighty per cent of the mileage in Indiana is included in one of these marked roads, 86 per cent in Nevada, 54 per cent in Arizona, 50 per cent in Washington, while in Pennsylvania and New York, which have already constructed most of the roads of this category, the mileage represents 15 and 17 per cent, respectively, of the whole mileage of Federal Aid roads. In thus referring to the mileage of our roads which is included in these selected routes, it is not intended to convey the impression that such routes constitute a desirable or complete system of national roads. Indeed, it is safe to say that no one of such roads is laid down at all points in the most suitable location. In many instances we believe that sections of our roads which do not fall on the lines of these routes, will better serve the transcontinental traveler than the selected routes, but in the main these widely advertised roads do follow the natural lines of travel.

In order to provide a more rational basis for co-ordinated work on the part of the states, the bureau, in conference with the advisory committee of state highway officials, has initiated plans for a nation-wide survery of the roads of the country, and a classification of all highways in respect to their importance and character of service. The survey when completed will doubtless furnish the necessary data for the establishment of a classified system of highways similar to the French system.

Already the bureau is co-operating with the War Plans Division of the General Staff and the Corps of Engineers of the War Department in a study the purpose of which is the selection of those highways which are important from a military standpoint, though at the outset it is recognized that the highways which are required for commerce and national development are in general identical with those required for military purposes. This work, which has been undertaken by the War Department at the suggestion of the bureau, is being assisted in every way possible. The detailed studies are being conducted by the department commanders, and the bureau is supplying maps and necessary information relative to highways under consideration.

The recommendations of the several department commanders will be co-ordinated under the direction of the General Staff and furnished to the bureau as a complete report covering the highways of importance from a military standpoint in the United States. When received the recommendations in this report will be given careful consideration and will be taken up in conference with the state highway departments with a view to expediting the improvement of these highways as a part of the Federal Aid program.

Considerations in Determining Adequacy of Federal Aid Projects.—The requirement of the act that the construction of Federal Aid roads must be of a substantial type must apply with equal force in the desert of Nevada and the densely populated areas of New England, New York and Pennsylvania. In considering types of construction which may be approved for Federal Aid it has been impossible to apply fixed and definite standards because no standards can be found which will meet the variety of conditions presented throughout the country.

Without, therefore, setting up definite requirements of construction or stipulating that roads of a certain type or types only shall be constructed, it has been necessary to apply more fundamental considerations to determine the adequacy of roads proposed by the states as Federal Aid projects. The considerations applied in determining whether a particular project is adequate and of a substantial type may be grouped under four general classes.

The first class refers to traffic, and under this heading each project is considered with respect to—

(a) The amount of traffic at present using the road.

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*Based upon reports from all States except Florida and Louisiana.

[illegible] road [illegible] to [illegible] a [illegible]

(b) The relation of the proposed road to the state road [illegible]

[illegible]ul and adequate improvement of adjacent or con[illegible] will be adequate under traffic likely to develop; and the part which the new road will play in the general state system is further indication of the probable future traffic.

Because of abnormal conditions in the materials market during the past year and the difficulty of securing transportation facilities, many projects have been affected; but entirely aside from these abnormal conditions, which temporarily affect materials and methods of construction, a third group of considerations is applied in determining the adequacy of Federal Aid projects. The elements of this group are—

(a) The quality and kind of local materials available for construction.

(b) Peculiar local conditions affecting construction.

(c) Prevailing practice in highway construction in the state or locality.

It is frequently found that suitable local materials are so much less costly than better materials imported from a distance that the construction of a lower type of work with the local material is justifiable, and as it is important to develop material sources throughout the country on as large a scale as possible, approval of the use of local materials is not infrequently made for the purpose of encouraging local production. There are also occasional peculiar conditions affecting the methods of construction. For instance, in parts of the far West the entire absence of water along a right of way and the expense of piping an adequate supply for 20 or 30 miles makes the construction of any type requiring large quantities of water uneconomical, and under these conditions other types are approved which can be constructed without the use of large quantities of water. The local practice must occasionally be considered, because of the difficulty of securing contractors when unusual or strange requirements regarding the work are insisted upon. For this reason the prevailing practices of the state in certain details of construction are admitted as affecting the design and type of work.

The last group of considerations is of a more technical nature and is at the present time confined to the results of experiments and studies made by the bureau and believed to be applicable to a greater or less extent in determining the substantial nature of proposed pavements. These experiments have to do with the resistance of the commoner types of pavement construction to impact and to the effects of heavy motor truck traffic. Studies of soil conditions in progress under the direction of the bureau likewise furnish additional information which can be applied in determining whether the designs for bases and sub-bases of pavements are adequate.

With these several considerations in mind the initial decision as to the type of a particular road is made by the state highway department. Its decision is reviewed by the bureau after an independent study of the conditions, and the type of road finally decided upon is that type which in the judgment of the engineers of the state department and of this bureau is the most suitable under the circumstances.

The types of road selected and constructed in this manner have included practically all the well known forms of construction from unsurfaced earth roads to high class concrete, brick, and bituminous concrete roads. In point of mileage the low types of earth, sand clay, and gravel represent about 66 per cent of all the roads constructed; the intermediate types of water-bound macadam and bituminous macadam, etc., constitute only about 7 per cent; and the high types of concrete, brick, bituminous concrete, etc. (including a considerable mileage the type of which has not been definitely decided, but which will be surfaced with one of the higher types of pavement), involve about 24 per cent of the total mileage.

A hasty conclusion drawn from these statistics might make it appear that the Federal funds are being spent to too great an extent on roads of relatively unsubstantial character. On the contrary, the bulk of the money is being expended for roads of the high and intermedite type—60 per cent for the former and 9 per cent for the latter—and only about one-quarter of the money allotted has gone for the roads of the lower type, which constitute 66 per cent of the mileage. Not only, however, is the major portion of the Federal money expended for roads of the higher type, but the roads themselves are of distinctly higher type, in the average, than the roads constructed by the state highway departments.

The following table shows the classified mileage of roads supervised by the state highway departments during the calendar year 1919, as reported to the bureau by the several departments. In the parallel columns the mileage of the types of Federal Aid road is repeated for purposes of comparison. Percentages of each type and each class are shown for the Federal and state roads. It will be clear from an examination of this table that the Fedral Aid roads are relatively more substantial in the average than the roads built under state supervision alone.

[illegible] OF [illegible] FOR WHICH [illegible] HAVE BEEN [illegible]

[illegible]	Miles.	Per cent [illegible]	Total cost.	[illegible] total cost.
[illegible]	[illegible]	21.5	[illegible]	7.7
[illegible]	[illegible]	10.0	[illegible]	3.5
Shell	27	0.2	296,801	0.1
[illegible]	[illegible]	32.5	47,151,795	16.8
[illegible]	355	2.1	4,136,533	1.5
[illegible]	342	2.0	5,258,779	1.9
[illegible]	97	0.6	1,433,499	0.5
[illegible]	[illegible]	4.1	16,669,782	5.9
[illegible]	[illegible]	[illegible]	1,978,293	0.7
[illegible]	[illegible]	2.9	15,064,756	5.3
[illegible]	[illegible]	19.2	120,629,308	42.9
[illegible]	[illegible]	2.0	15,725,494	5.6
[illegible]	[illegible]	0.3	1,572,472	0.6
[illegible]	[illegible]	2.3	19,796,607	7.0

[illegible] SUPERVISED BY STATE HIGHWAY DEPARTMENTS

[illegible]	Federal aid roads.			Roads supervised by state highway departments, 1919		
	Miles.	Percentage each type.	Percentage each class.	Miles.	Percentage each type.	Percentage each class.
[illegible]	3,701	[illegible]		7,212	41.4	
[illegible]	1,721	10.0		843	4.8	
[illegible]	27	0.2	[illegible]		..	75.0
[illegible]	5,583	32.5		5,035	28.8	
[illegible]	355	2.1			...	
[illegible]	[illegible]	2.0		1,446	8.4	
[illegible]	97	0.6			...	
[illegible]	[illegible]	4.1	7.0			12.0
[illegible]	51	0.3		945	5.4	
[illegible]					.	
[illegible]				375	7.9	
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	11.3
[illegible]		0.3		128	0.8	
[illegible]		[illegible]		293	1.7	

[illegible] EXECUTED

[illegible]	Project agreements executed.		
	Number of projects.	[illegible] cost.	Federal aid granted.
[illegible]	[illegible]	[illegible]	$ [illegible]1,717
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	454	41,631,732	18,048,442
[illegible]	[illegible]	[illegible]	85,906,556

[illegible] annual reports for those years. As projects are [illegible] from the figures here given will not agree with the [illegible]

Mechanical Loader Cuts Road Concreting Crew to 13 Men

A mechanical loader which picks up the aggregate from ground storage piles, measures it to correct proportion and conveys it to the mixer, was the outstanding feature of a road job at Carrollville, Wis., on which the Jacobus & Winding Construction Co. of Milwaukee was the contractor. By the use of this machine the crew was reduced to 13 men, nearly all of whom were skilled workers, the manual labor in connection with the work being almost entirely dispensed with by the loader.

The roadway was 20 ft. wide 7 in. and 8 in. concrete, 1:2:3½ mix, reinforced with wire mesh. A 2-bag mixer was used. The work was carried on under conditions which proved about as bad as any ever encountered in road construction. A large part of it was through deep cuts and the subgrade was in exceptionally bad condition as a result of continued rain and poor drainage. The necessity for completion of this work before cold weather set in, compelled the work to go on in spite of these adverse conditions. Due to the absence of any manual labor in shoveling or wheeling over a muddy subgrade, it was possible to carry on construction work in spite of the fact that the rain interrupted the work every few days. It was found that the machine could operate regardless of sub-soil conditions and nothing but actual rain could stop the progress of the work.

Construction View of Carrollville, Wis., Road Job.

The mixer loader used, consists of a long framework mounted on self-propelled trucks which carries a rubber belt conveyor which discharges the material through a chute into the mixer skip. On the top of this framework a bucket elevator is mounted so as to move back and forth along the frame to adjust it into working relation to the piles of sand and stone adjacent to the loader. Underneath this elevator and above the belt conveyor a hopper is mounted which is divided into a number of compartments and is movable along the frame so that anyone of these compartments may be placed in position for the elevator to discharge into it. In operation the elevator first fills a series of sand hoppers sufficient for eight batches and then moves into position to elevate stone, for which two hoppers are provided. When the elevator fills a stone hopper it is discharged, together with a sand hopper, onto the belt and carried to the mixer. When the last sand hopper is discharged, the elevator is moved to the sand pile and in less than two minutes will refill the eight sand compartments. During this time the two compartments of stone are ready for delivery to the mixer so that no delay results in changing the elevator from one pile to the other.

The elevator is built in the form of a separate unit and is operated by a four cylinder motor. The belt conveyor, the traction, and the hopper are driven by a second engine located at the rear of the framework. The two power plants are identical.

The material is spouted into the mixer skip by means of a swivel chute pivoted at the end of the framework. The purpose of this chute is to enable the material to be spouted well toward the inside of the skip and also to allow considerable variation between the mixer and loader so that exact alignment is unnecessary. This proves to be a considerable time saver in moving.

The material was spotted in piles at one side of the road. It was delivered by trucks and four piles were made in 50 ft.—sand and stone were placed alternately. The range of the elevator being a little over 50 ft. enables it to work on any one of four piles with one setting of the machine. Considerable additional range is provided by the swivel chute which can be extended either forward or backward to discharge the material into the mixer skip. In this way a total variation of 70 ft. is possible in the piles.

By placing material on one side of the road the other side was left open for bringing up additional material and cement. On this job sufficient room was left between the loader and the forms to bring up cement in wagon loads and pile it within 20 ft. of the mixer. The piles of sand and stone were approximately 12 ft. wide, two to three truck loads being dumped on each pile. These were almost completely picked up by the elevator, only one man being required for cleaning up. This man was able to clean the material up thoroughly enough so that the loss of material was negligible.

On one side, forms were set several hundred feet in advance of the mixer and on the other side they were set as far as the piles of material permitted. The inclined section of the conveyor extends to a height of about 12 ft. and permits a length of about 30 ft. between the skip of the mixer and the wheels of the loader for finish grading with sufficient head-room for men to work without danger. As previously stated, although the subgrade was in exceptionally bad condition and needed considerable trimming, still this 30 ft. of working space was all that was ever required.

The crew consisted of 13 men, placed as follows:

1 finisher.
2 men spreading mixed concrete and laying reinforcing.
1 mixer engineer.
1 fireman (helper on loader chute).
2 cement men.
2 men for preparing the grade.
1 loader engineer.
1 man operating hoppers on loader.
1 man cleaning up material piles.
1 form setter.

This crew required considerably less supervision than the ordinary mixer crew, chiefly because only half as many men were required and most of these were skilled workmen who in turn set the pace for the laborers. Considerable economy was effected outside of the direct saving in wages by such a reduction of the crew. Labor turn-over was almost reduced to nil, most of the men being old and steady employes.

The crew was transported to the job from Milwaukee, a distance of 15 miles, by three of the men who owned Fords, the contractor paying these men the equivalent of the train fare for transportation.

Weather conditions and other delays beyond the control of the contractor and later freezing weather, interrupted progress of the job to such an extent that accurate data regarding average production would mean very little. The average progress of the work was approximately on the basis of 30 ft. per hour.

Shipping and Storing Road Building Materials During Winter and Early Spring

[illegible] from [illegible] contrac- [illegible] time, [illegible] his men may fail to show up for work some mornings, a piece of equipment may go wrong, he may not have material, etc., etc. [illegible] on a [illegible] season [illegible] days to his credit. The contractor is constantly trying to anticipate and prevent these delays. He adopts methods and plans his work to overcome as far as possible delays because of rains. To eliminate labor trouble he buys modern machinery that does work formerly done by hand. But his biggest delays have been because the railroads have not delivered material to him regularly during the construction season. In an effort to remedy this condition The Lakewood Engineering Co. sent letters to contractors, highway engineers, banks, chambers of commerce, railway officials and others interested or concerned with the country's highway program, pointing out that: If road materials are transported and stored during the winter and early spring months when open-top cars are more available than they are during the construction season, the contractors could proceed with considerable less interruption and their working season would be increased accordingly.

Many replies were received to these letters. Most of them are in hearty accord with the plan suggested and offer help in making it a success. Several letters tell what has already been done along this line. For instance, at Ogden, Utah, materials for 20 miles of road were shipped in last winter, and this road was completed during the past season in record time. The state of Delaware has followed this practice for three years. The Board of Freeholders of Passaic county, New Jersey, have acquired a central storage yard for stockpiling road materials this winter. An Illinois city, Belleville, has already stored cement for next season's work.

It is surprising that the idea is apparently new to many. It was strongly urged last year by several state highway departments, as well as the U. S. Office of Public Roads. Nevertheless, many of the letters indicate that the idea is a new one in many parts of the country. The arguments for the delivery of highway materials in winter, in brief, are set forth as follows:

In general there is a surplus of open-top cars in winter, which should be utilized.

Payment by states for materials when delivered is possible in 28 states, but it not possible in ten under present laws.

Prices of materials will probably not fall by spring, therefore it is just as well to buy now, borrowing the money if necessary.

Frozen road materials are not difficult to unload and can be handled in the winter far better than a road can be laid late in the fall, due to delayed deliveries in the summer.

If there is an active market, quarries will continue operations in the winter to meet the demand, possibly remaining [illegible]

Insuring Proper Contour at Street Intersections.—Construction of a wide street intersection at Garner, Ia., was simplified by the use of two small concrete pavement blocks. [illegible] Magazine, also served as platforms on which the workmen [illegible]

Binding and Preserving Files of Engineering and Contracting

BY ROBERT S. STOCKTON.

The readers of technical magazines who are permanently stationed outside the cities can well afford to keep files of magazines which have helpful articles on nearly every subject of interest to engineers. The use made of such magazines depends on having them conveniently bound and indexed. The writer has made a practice of removing the advertising matter, and sewing the sections, but this involves too much labor.

For individual and office use, it is not necessary to have these volumes of the magazine bound by a regular bookbinder, or in permanent form, as is desirable for a library, but some form of binding the magazines after removing the large bulk of advertising pages, is necessary for convenient handling and use and so that they may be stored in a small space.

The clipping and filing of articles under certain heads may answer the requirements of some engineers; but it frequently happens that the thing most wanted is not saved, and besides hunting through a filing system is less effective than going through the index of several volumes of Engineering and Contracting.

Most engineers also desire to keep up with matters outside their specialty, as they never know when their interests may lead to another line of work, which is another reason for saving complete files of important technical publications.

The method now used by the writer for binding the volumes of magazines that are worth saving is as follows:

First remove the metal clips used by the bindery, and strip off the paper cover and advertising sections. This process is facilitated if the printer will arrange his sheets so that the printed matter is folded together in one or two sections, so that it separates from the advertising matter without having to cut the pages containing advertisements away from the printed matter sections.

In any event, separate the printed matter and arrange it in order with the index and fly leaves if desired. The simplest cover is made from two of the outside covers of the magazines. Since the volume to be bound is much thicker than a single magazine, the covers will not reach clear around from edge to edge, but the front cover can be be placed last so it will, for the front or top cover of the volume, present to the eye, the front magazine cover selected, showing the proper year, volume number, and name of the magazine being bound. In the case of Engineering and Contracting, if you are principally interested in Water Works and Hydraulics, take a cover bearing that headline. The interlapping covers can later be pasted together if desired or a heavier cover can be built up.

Next take two smooth pieces of board about 18 in. long and 3 in. wide. Near each end bore holes and put through a ⅜ in. x 4 in. bolt with a square head. Over each bolt head, nail a block with a square hole dapped in to fit the head and prevent the bolt turning. Use two wing nuts about 3 in. long and you have a convenient clamp that can be used for binding a variety of papers. Three holes 3/16 in. diameter are bored about ⅝ in. from one edge and spaced 4 in. apart, which is suitable for binding letter size paper or anything not much larger. Other holes may be used with a different spacing if desired for binding odd sizes of paper.

Now for the binding. Place the volume as prepared in the clamp, keeping the back as straight as possible; tighten the wing nuts so the volume is held firmly as it is to be bound. Next take an ordinary 3/16 in. machinist's drill in a carpenter's brace, or better, a machinist's breast drill, and bore three holes straight through the volume at the desired distance from the edge and guided by the three holes in the wooden clamp.

After the holes are bored, remove the volume carefully from the clamp and at once insert three heavy brass paper clips of the proper length and weight. When these clips are turned down and fastened, the volume will be neatly and securely bound and will last indefinitely with careful use.

The clamps are simple and inexpensive, and the breast drill will be found in most any shop, or an outfit can be purchased and will be of use as long as wanted.

This system of binding is in use in our office to bind typewritten reports, etc., sometimes with a cover of blueprint tracing cloth, or ordinary detail paper. The method has been found so simple and useful that it is described as a suggestion to others who may be interested.

Snow Removal in American Cities

The importance of keeping at least the main municipal arteries of travel free from snow is growing rapidly as a result of the increasing use of the motor vehicle for municipal and business purposes. The solution of the snow removal problem in cities is, therefore, of prime importance. In order to make available to municipal officials complete and up-to-date information about snow removal methods in American cities, the kind of apparatus now used and the suggestions and opinions of experts and others who have studied the subject, the New York State Bureau of Municipal Information has sought reports from American cities and has summarized all printed material it has been able to find on the subject. These data are given in a report of the Bureau issued on Nov. 20, which summarizes the information as follows:

The heavy investments in motor trucks for cartage and transportation, the motorizing of municipal police, fire and public works equipment and the increasing use of pleasure cars during the winter, make the use of motor vehicles the entire year a matter of municipal concern. Already many city administrations have recognized this changed condition, and it is the general belief that within a very short time all municipalities will appreciate the need of snow removal, and act accordingly. In a recent article Harry R. Hayes, former Commissioner of Public Works of Utica, says: "Today any slight street congestion caused by snow conditions not only retards transportation in the commercial and manufacturing fields but also seriously affects the efficient operation of motorized fire equipment and disrupts the important work of garbage and refuse collection and removal. There is need for extended snow removal work to afford parking spaces for passenger vehicles. The business men in the store districts show a strong desire to have the streets kept cleared of snow for business reasons. They realize the necessity more each year for clean and uncongested streets both in summer and winter. It is also generally recognized that the more work that is directed on snow removal, the less ice there will be to remove, and the less amount of street cleaning there will be to do in the spring. It will also affect the cost of fire fighting and garbage and ash collection."

There are three distinct methods of attacking the problem:

(1) Clearing streets for traffic.
(2) Snow removal.
(3) Snow fighting.

Reports from New York State cities show that in the smaller communities and even in some of the large ones, the snow is either packed down or cleared to one part of the roadway. If this accumulation becomes too great, a part or all of it is carted away. In some cities all of the snow is removed in the congested district and the streets in the residential districts are simply cleared for traffic.

Until recent years it was the custom in all cities to wait until the storm ceased before beginning snow removal. Several cities now recognize the efficacy of beginning work while the snow is falling. These cities have a snow alarm which sounds whenever indications point to a heavy fall of snow or when a certain amount has fallen.

Efficient snow fighting methods involve three things:

(1) Preparedness.
(2) Organization.
(3) Equipment.

It is generally agreed that a city which removes snow in at least its main arteries of travel, should start work before the snow becomes too deep. When the snow fall is allowed to accumulate or to freeze, the problem becomes serious.

All who have been interested in the subject emphasize the importance of preparedness and thorough organization. Some of the cities have very comprehensive organizations.

The consensus of opinion is that wherever possible effective machinery should be used and thereby reduce to a minimum dependence on labor. It is pointed out, however, that care should be exercised in investments for equipment, as machinery used exclusively for snow fighting is idle so much of the time that every effort should be made to use such available apparatus that the city has and that can be temporarily converted into use for snow fighting. In the spring, summer and fall this apparatus can be used for other municipal service.

Utilization of Existing Macadam as Base for Bituminous Pavements*

By JULIUS ADLER,
Technical Engineer, The Atlantic Refining Co.

The following advantages have been claimed for the use of macadam as a foundation under asphalt pavements of various kinds:

Economy in utilizing existing macadam pavements.

Lower cost (depending upon available materials, labor rates, etc.) of construction of new macadam base as compared to Portland cement concrete.

Freedom from the transverse cracks that develop in bituminous surfaces on Portland cement concrete due to the contraction and cracking of that type of base.

Slight resiliency of the macadam base, which reduces the hammering or anvil effect produced upon an asphalt surface laid on unyielding base.

As an illustration of opinions from disinterested sources, a city engineer of a southern town states that bitulithic stays put on a macadam base very much better than on concrete; that a properly prepared macadam foundation is quite elastic, absorbing a considerable portion of the shock of heavy auto trucks and in throwing the entire burden of impact upon the wearing surface. Numerous similar views held by engineers could be cited.

In contrast to this viewpoint is the growing tendency in some localities to disregard the possible value of macadam road as a base, usually because it is considered inadequate under all year round heavy motor truck traffic. This opinion is supported by reports from a number of localities of serious damage to both macadam roads proper and macadam based types during the winter of 1919-1920. In view of the wide variations in climatic and other local conditions, in volume and weight of traffic, broad statements in regard to either the merit or lack of merit of such construction should be accepted with caution since success or failure in any particular case may be attributed to strictly local conditions.

Supporting Power of Factors Affecting Macadam Base.—To determine the limitations of a given type of paving construction it is necessary first to establish the factors affecting the strength and durability and, second, the application of these factors to a specific case. For the type under consideration, the factors are:

1. Strength of base.
2. Variation in supporting power of the earth subgrade.
3. Volume and weight of traffic.

Under this heading come such elements as the total depth and degree of consolidation of the base, the size of the units used as aggregate, and the strength and durability of the aggregate. Other things being equal, the greater the depth of base, the greater the area of sub-base over which the road is transmitted.

Consolidation refers to the thoroughness with which the pieces of aggregate have been forced into place during construction and by the action of traffic; it being generally conceded that traffic affects this more reliably than rolling alone.

Under size of aggregate units must be considered the relative value in the base of stone 1½ in. in diameter or less, ballast-size stone and large pieces such as used for Telford base, respectively. Results in general point very closely to the greater value of the base employing the largest possible size of aggregate, which affords greater stability, better distribution of loads, freer drainage and less disturbance by frost.

Strength and durability refer to the quality of the aggregate material, whether soft, shaley, porous or dense and tough. It is generally well established that base material does not need to be so hard and tough as that in the wearing surface.

Variation in supporting power of the earth surface is a factor which causes the most serious damage. The supporting power is affected primarily by the character of the soil, natural and artificial provisions for drainage, and climatic conditions such as amount of rain and snow fall, depth of frost action and likelihood of alternate freezing and thawing.

Under the light traffic of years ago a macadam road de-

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*Abstract of a paper presented at the 26th convention of the American Society for Municipal Improvements, St. Louis, Oct. 12-15.

[illegible] form support by the subgrade itself. On free draining soils, generally sandy or gravelly, very light macadam base has carried considerable traffic with entire success. Where natural drainage is poor, artificial drainage is absolutely essential. Everyone seems to realize this but comparatively few carry [illegible]. In some conditions such as heavy clay soil in flat sections subject to severe frost action where no prevailing method of drainage will give the subsoil sufficient strength.

Alternate freezing and thawing are especially detrimental. Numerous conditions can be cited where the temperature remains uniformly low enough in winter to keep the earth frozen continuously and prevent the percolation of water into the soil during this period, where the roads have stood up successfully. The critical time under such conditions is when the frost leaves the ground in the spring.

For macadam base, probably the most important point in connection with traffic is that of the likelihood of the use of the road by heavy concentrated roads during the winter and the spring. In sections where traffic practically disappears through the winter and does not reappear in quantity until the subgrade is pretty well dried out in the spring, the damage by heavy traffic may be relatively slight. In general, the most severe damage is found in localities where heavy motor trucks use the roads throughout the year and especially during February, March and April.

Assuming the above to be a correct analysis of the factors in the supporting power of macadam, the problem remains of applying these to individual cases and attempting to determine in advance which ones would be apt to shorten the life of the foundation and the overlying pavement.

Improvements to Old Macadam Base Preparatory to Bituminous Work.—Recent recommendations for this type of base vary from 4 to 12 in. depending on individual opinion as well as soil and drainage conditions. There has been a tendency to overestimate the depth of existing macadam arising largely from failure to realize that, while additional stone has been added year by year to the surface, an equal or even greater amount may be worn off meantime by traffic.

Before using an old road, the depth at numerous points should be determined by test holes, which also will indicate the character of the existing aggregate. In general it is believed that where an old road contains 6 or 8 in. of compacted stone it is well worth saving. But no radical view should be adopted as to the minimum thickness of base that will support a proposed pavement.

The writer believes, however, that 4 to 6 in. is not sufficient in the northeastern section of the country, especially near large cities. Even where ample depth is found, it is usually desirable to add a uniform layer of ballast-size aggregate, first scarifying the surface, the new aggregate serving to elevate the proposed bituminous pavement above the old base which, owing to the large amount of dust and fine [illegible] is very apt to hold considerable [illegible] of the year. While this disturbs [illegible] consolidated road, an old road which will not stand disturbance for this depth will generally [illegible] foundation in any case. [illegible] of a base to [illegible] add to the life of [illegible] to offset the [illegible] is apt to [illegible]. By admitting [illegible] be [illegible] be [illegible]

[illegible] being built. Too frequently this is [illegible], ditches too close to the im- [illegible]

[illegible]

[illegible] of the pavement laid upon it. This will furnish greater resistance to the thrust on the foundation [illegible] loads travelling slowly on the sides of the road than is now encountered; provided, however, that the improved road is not so narrow that heavy traffic is constantly cutting off and on it.

As a further improvement, the shoulders should be waterproof and support furnished at the edges of the bituminous pavement. Cases have been noted where the existence of an old macadam shoulder, even though rather thin, has been of material benefit. Well built stone block or rubble gutters and headers produce a similar result. If no better provision can be made, stone removed from the old surface can be used to harden the shoulders and additional aggregate brought in where required.

One of the best practices for country roads is the construction of bituminous macadam wings 3 or more feet wide which provide waterproofing and lateral support to the pavement and at the same time furnish a hardened surface capable of carrying occasional loads. At least there should be on each edge a strip of hardened surface 18 to 24 in. wide like the base previously referred to. This may be criticized as calling for a greater width of road and consequent cost than would be required if some other type of construction were used, but in its support it may be said that the change from the approved width of 15 ft. of a few years ago to the present demand for 20 ft. as being desirable, points unmistakably to the necessity for providing ample width at the outset. Also roads of other types built 16 to 18 ft. wide will eventually need protecting wings for the preservation of the pavement, inasmuch as a sudden drop off from a hardened surface to a soft earth or clay shoulder is objectionable from several standpoints. If too close to the edge of a pavement, open ditches allow moisture to get under the base and reduce the support, while if far away, leaving a wide unwaterproofed shoulder, there is too much opportunity for the entrance of water through the surface, especially when it is heavily blanketed with snow or ice. For country roads a shoulder of about 5 or 6 ft. wide is recommended, waterproof between the edge of the road and a point near the edge of the ditch.

Wholesale Prices in November

The downward trend of wholesale prices which began in June of the present year became more pronounced in November, according to information collected in representative markets by the Bureau of Labor Statistics of the U. S. Department of Labor. Measured by changes in the Bureau's weighted index number, which assigns to each commodity an influence proportionate to its importance in the country's markets, the November price level was 8 per cent below that of October and 24 per cent below the high peak reached in May.

Building materials showed the largest price recessions in November, the decline from the level of the previous month being 12½ per cent. Farm products followed next with a drop of over 9¼ per cent from the October levels. Cloths and clothing decrease approximately 9 per cent and fuel and lighting materials 8½ per cent, while metals and metal products register a decrease of more than 7½ per cent in comparison with October prices.

Of 326 commodities or price quotations included in the comparison for October and November, 198 showed a decrease and only 41 showed an increase. In 87 cases, no change in price was recorded. Of these, a majority belong in the groups designated as cloths and clothing, fuel and lighting, metals and metal products, and building materials.

Below are shown the index numbers of wholesale prices in the United States, by groups of commodities, as computed by the Bureau of Labor Statistics for the month named. The figures for the last named month are preliminary and subject to revision. The base used in computing these index numbers is the average for the calendar year 1913.

INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES.
(1913 equals 100.)

[illegible]	1919. November.	1920. October.	1920. November.
[illegible]	240	182	165
[illegible]	219	204	195
Cloths and clothing	325	257	234
Fuel and lighting	179	282	258
Metals and metal products	164	184	170
Building materials	236	313	274
Chemicals and drugs	176	216	207
House-furnishing goods	299	371	369
[illegible]	229	229	220
[illegible]	230	225	207

Handling the Highway Snow Problem

An interesting résumé of the methods employed by highway departments of various states for handling the snow problem is given by Mr. J. L. Harrison, Senior Highway Engineer, U. S. Bureau of Public Roads, in a recent issue of Public Roads, a publication of the bureau. We quote from the contents as follows:

The actual work of snow removal that will be done this winter is handled in pretty much the same fashion by all of the States. It is the common and the logical practice to turn this work over to the maintenance department. In most states the maintenance departments are now well organized, and the addition of snow-removal work to the previously assigned duties of the maintenance department has the advantage of making what, for the lower grades of employes, has been a seasonal occupation into a full-time position. In the long run this will have a very beneficial effect, for it will make it possible to obtain and to keep a better grade of men.

The methods used in handling this snow problem are also similar in all of the states. Indeed, they resolve themselves into two distinct groups of activities:

(1) The removal of snow from the highways and

(2) Preventive methods tending to keep it from blowing into the highways in objectionable quantity.

These naturally go hand in hand, but as the expense of removing snow is apt to be greater than the expense of preventing it from accumulating on the roads, the preventive methods will be treated at the greater length.

Preventive Measures.—Snow, of course, falls uniformly and sometimes lies as it falls. More generally, however, there is some wind in connection with a snowfall, and when this is the case there is, depending on the velocity of the wind and the character of the snowflakes, more or less drifting. Snowflakes are carried along by air currents just as sand and silt are caried by water currents. Moreover, the greater the velocity of a wind current the more snow it can carry. And herein lies the cause of drifting, for wherever an air current that is carrying snowflakes is checked some of the snowflakes are, perforce, dropped, and as this continues a drift is formed, the whole process being quite the same as that by which sand bars are formed in water currents.

It should be noted, however, that in general the snow that is moved about by the wind is not raised very far above the surface of the ground. The distance that it is raised depends, of course, on the velocity of the wind, but it is only in exceptional cases that the wind is so high that the snow is caried at an elevation which prevents the control of the area in which it will be deposited.

Snowdrifts are formed on the lee side of obstructions. This naturally follows from the fact that back of such obstructions there is a body of relatively quiet air. Indeed, the velocity of an air current may be affected for as much as 10 times the height of such low obstructions as fences, hedges, etc. From this it naturally follows that where snow is being carried by wind, low obstructions will clear the air current of snow by causing it to be deposited in a relatively quiet space back of these obstructions.

This matter has been treated at some length because of its relation to all of the means that must be adopted for preventing the formation of drifts. These begin with the removal from the right of way of everything that can cause drifting. Weeds are the most common source of trouble. These should be carefully cut down and removed, for a growth of weeds or high grass, even if no more than a foot or two high, will cause drifting whenever the wind is right. Moreover, this applies even to such places as the tops of fills that would otherwise blow clear. Too much emphasis can hardly be placed on this matter, for more drifting is caused by weeds and brush allowed to accumulate along the roadway than in any other way. The weeds should, of course, be kept down by constant trimming, but if this has not been done they should at least be cleared away in the autumn and the right of way left unobstructed during the winter months.

Hedges, Fences, and Trees.—Next in order of importance as causes of drifts on the highways are the hedges. These should be removed wherever experience has shown that they cause trouble. A hedge will, of course, cause drifting whenever the wind is right, but there are many regions where the winds that carry snow are so constantly from one direction that only a relatively small fraction of the hedges need to be removed to correct practically all of the trouble originating from this cause.

Stone fences, rail fences, picket fences, indeed, all of the tight fences, can and often do cause drifting. To reduce drifting to a minimum, such fences should therefore be taken out and wire fences erected in their places, for wire fences, being open, offer no obstruction to the wind and so do not create a condition under which snow will be deposited.

Rows of trees sometimes cause drifts to form. Where this is the case it will generally suffice to trim the branches well above the ground. Sometimes, however, this is not sufficient, and the trees themselves must be taken out. At this point measures of snow removal come into conflict with roadside beautification and home or town improvement and a problem is created that can not be solved with the snow problem solely in mind. Indeed, this same applies to some extent to the removal of fences and hedges, and, in practice, it will be found that in spite of the obvious advantage of removing such obstructions there may arise even more patent disadvantages which will prevent the complete elimination of all of these sources of trouble.

Besides the above causes of drifting there are conditions lying in the topography of the country and in the manner in which roads have been built that tend to cause drifting. A hill may affect the air currents a good deal. A cut may be so placed that it catches the flying snow. Matters of this kind can not be corrected by eliminating the cause of the drifting, however, a good deal can be done by erecting snow fences,

As has been stated above, the snow that is carried by the wind is usually carried near the ground. Where cuts drift full, or where the general contour of the country causes drifting, snow fences may be so placed that the air currents will be cleared of snow before they pass over the road.

To accomplish this, such fences should be erected on the windward side of the road and from 50 to 60 ft. distant. These fences may be either permanent or portable, but as rural highways quite generally run through land that is used for agricultural purposes, the portable fences have the wider adaptability in highway work, for they can be set up after all crops are removed from the land and removed in the spring before the land must be worked for the next year's crop.

Snow fences are generally either of the "board fence" type or of the picket type. The permanent fences are generally of the board type. Eight 6-in. boards, separated from 2 to 4 in. on the nailing strips, make a very satisfactory fence for this purpose, the portable fence of this type differing from the permanent installation only in that it is made up in sections of convenient length and held in place by stakes or driven posts rather than by set posts.

Picket fences are often used where a portable fence is required. The best fence of this kind is one made of light pickets held in place by a number of strands of heavy wire. Such fences can be readily erected on driven posts and when out of use rolled up and stacked where they will be out of the way.

Where Preventive Measures Fail.—After all of these preventive measures have been resorted to, there will still remain to be handled all of the snow that lies as it falls and such minor drifting as can not be economically handled by the erection of fences and this may amount to a good deal, for, ranging from little or nothing in the southern part of the country, the normal snowfall increases to the north, until in many parts of the northeastern, northwestern, and northern Lake regions it exceeds 100 in. a year. Indeed, in the regions where there are heavy snowfalls the problem of keeping the highways clear is a serious one even after all preventable drifting has been eliminated, and it is not an easy one to handle though the snowfall is only moderate.

There are really only two methods of keeping roads open to traffic where the snow is heavy—the compaction method and the removal method.

Opening Roads by Compacting the Snow.—Solving the snow problem by compaction consists of rolling the road after every snowfall with a roller 6 or 8 ft. in diameter and from 10 to 12 ft. long. To insure that the roller shall work well, the ends must be closed. Two widths should be rolled so that vehicles can pass without either one getting off of the compacted snow.

This method does very well where the traffic is light and is composed principally of horse-drawn vehicles and possibly a few light automobiles. It is not, however, satisfactory for [illegible] in two narrow wheel tracks, may [illegible] thereby.

[illegible] formed only when the snow is compacted. At a matter of fact they are still more readily formed where nothing at all [illegible] of the best reasons for removing the snow from the highways lies [illegible] if the traffic is of [illegible] done the highways is often much greater than the cost of removing the snow would have been.

[illegible] must be kept clear and the traffic is such that compacting the snow is not sufficient, there remains nothing but the removal [illegible] of plows or by hand. Sometimes rotary plows are used, but as yet they have not been commonly adopted for this work in this country. Ultimately, the writer believes, the heavier snowfalls will be handled by some form of apparatus resembling the modern elevator grader. Such a machine might be readily designed to clear the full width of the highway at a single cut and, by using a fast-moving belt, to discharge the snow well away from the line of travel and where it would tend to prevent rather than to stimulate further drifting.

The present practice in snow removal is, however, to push the snow off the highway by means of blades similar to those used on road graders. Indeed, road graders are frequently used for this work, though the more common practice now is to fasten a heavy blade ahead of a heavy truck and to use the [illegible] the highway. Sometimes, and this applies particularly where the fall of snow is heavy, a second truck is used, this truck being hitched ahead of the truck that carries the plow. In this way a heavier plow can be used and the deeper snow thrown aside.

Operating in this fashion, all equipment must be kept available at all times and must be set in operation whenever the [illegible]rdless of the day or the hour. The pres[illegible] work as soon as from 2 to 3 in. of snow [illegible]n and to continue operations as long as the fall continues. The snow may be removed from the center to both sides, but in order to prevent drifting it is better to move all of the snow to the leeward side of the road. Even then some drifting may result from piling up the snow, but much less than will result from any piling of the snow on the windward [illegible]

The first clearings of the season should be wide enough. Indeed, the best practice is to clear at least 10 ft. more than the traveled way. If an 18-ft. road is being cleared this will mean that one cut should be made beyond each edge of the road surfacing where the snow is thrown to both sides, or [illegible] where all the snow is piled on the lee side of the road. As the season advances, this extra space will be used to store the [illegible] early part of the winter that cutting this extra width is a considerable inconvenience, it will usually prove a time saver [illegible]

[illegible] Early. The success or failure of this sys[illegible] the truck must be kept in constant operation as long as the storm continues if the final result is to be an open road. However, if the trucks are set to work early and kept at work regardless of the weather, it will not often happen that other methods have to be resorted to.

On the other hand, occasion will arise when, due to high winds and the failure to provide proper snow fences, cuts will drift full in spite of all that the trucks can do; or, possibly, it might be more correct to say that, because cuts are relatively narrow if the snow drifts into them rapidly, the trucks will often be unable to find the space to store the snow that must be handled if such cuts are to be kept clear. When this happens, as it will from time to time, the usual method is to put men in with shovels and clear away the drift by hand. Work of this kind is expensive, so the temptation to clear a minimum width is strong, but the most economical width is not necessarily the minimum that will serve the traffic. If the major portion of snow removal is being handled by the trucks, in which case any further snow falling on the road must be pushed to one side as it falls, the cleared width should be wide enough to give the trucks a chance to handle the later falls when they come. Otherwise the cuts will be blocked almost at once and hand shoveling must be resorted to whenever there is a snowfall.

Snow Removal by Hand. When snow must be removed by hand, it is important that the laborers be furnished with large scoops and that even at some additional first cost the snow be so piled that it will hinder rather than assist the refilling of the locations that have been cleared. It is not generally advisable to load the snow in trucks and remove it entirely, but this is sometimes done, and, indeed, when the cuts that have to be made are both wide and deep this may be cheaper than casting to one side. Snow so removed can generally be disposed of by the simple process of dumping it over the edge of the nearest high fill.

The most expensive item in snow removal is the excavation by hand of the drifts that have gotten beyond the capacity of the snowplows. For such work as this there are now manufactured rotary plows that will cut out these drifts and cast the snow considerable distances to the side of the cut which they make. As yet these rotary plows have not come into very general use, largely, it is thought, because the removal of snow from the highways is a comparatively new thing. Their use is, however, bound to increase, for it is not at all likely even after all of the preventative measures noted above have been taken that drifting will be so thoroughly eliminated that the snowplows operated by the modern trucks can fully cope with the situation. Rather, it seems to the writer, that it will prove advisable to supplement the present equipment in most states by the addition of enough heavy plows so that a working space can be kept clear even through the cuts that are known to drift full during severe storms, thereby insuring that full efficiency can be had from the other equipment.

Just how rapidly this change in snow-removal equipment will be made will depend on the development of satisfactory rotary plows, but it can hardly be put off much longer, for the cost of shoveling out deep drifts is very expensive.

Cost of Repairing Pavement Cuts at Los Angeles.—During the fiscal year ended June 30 last, the street replacing department of the city engineer's office of Los Angeles, made 1,016,354 sq. ft. of pavement cut replacements. The cost, according to the annual report of John A. Griffin, City Engineer, was as follows:

	Per sq. ft.
[illegible]	$0.2933
[illegible]	.2592
Brick, 1,919 sq. ft.	.4263
[illegible]	.2689
[illegible]	.2802
[illegible]	.2764
[illegible]	.2647
[illegible]	.1243
[illegible]	.1034
[illegible]	.0014

The working force of the department varies according to the amount of work on hand. On June 30 it consisted of one superintendent, two clerks, two foremen, three asphalt gangs each consisting of one 5-ton truck and four men; three concrete gangs of four men and one 5-ton truck each; the concrete and asphalt gangs being under the direction of one foreman; and the oiled gravel force consisting of five 5-ton trucks and ten laborers, undr the direction of one foreman.

Asphaltic Concrete Wearing Surface on Gravel Base

By L. W. MASHBURN,
Consulting Engineer, Clarksdale, Miss.

In Coahoma county, Mississippi, upon completion of present contracts, there will be gravel roads, covering practically the entire county, and varying in age from about 12 years to those being constructed at the present time.

These roads have answered the purpose for which they were built in that they have made it possible for traffic to continue at all seasons, whereas at certain seasons, with the old dirt roads, traffic was practically stopped. But due to lack of proper mainenance and the natural wear from traffic, some of them have deteriorated to such an extent that they must be practically rebuilt.

Asphalt Plant of the Murray Construction Co. Where Material Was Mixed for the Building of Asphaltic Concrete Roads in Coahoma County, Mississippi.

Modern motor traffic has shortened very materially the life of a gravel road and there is a tendency toward the construction of more permanent roads. However, many thousands of dollars had been expended in the construction of the gravel roads and it would not be practical to consider abandoning these roads for the construction of the more permanent ones; hence it became a question of finding a means by which the present gravel roads could be improved to such an extent that they will compare favorably with the more permanent types and thereby save as nearly as possible the money already expended.

Laying Asphaltic Concrete Pavement on Sherard Road, Coahoma County, Mississippi.

After a careful study of the question it was decided that this condition could be met by the construction of a wearing surface of asphaltic concrete, applied directly on the gravel as a base and a contract was let for 10 miles of this type of construction as an experiment. The general conditions to be met and the methods of construction will be given below.

Sub-grade.—As this is a type of construction in which the base is already laid, the preparation of the sub-grade will not properly come into this article. However, some cases were found where it was necessary to provide new means of subdrainage and this was done by use of lines of tile laid with open joints. In all cases care was taken to see that the side ditches were of proper size and grade to take care of surface water, so that none would stand long enough to wet the subgrade.

Preparation of Base.—The construction proper began with the preparation of the gravel base and on this preparation depends to a great extent the life of the road. The old gravel road was 14 ft. in width and orginally about 8 in. thick and of good quality, cementing road gravel. Except in case of excessive wear, the cross-section of the gravel surface was not materially changed, but the holes and irregularities made it uneconomical to attempt to apply the asphaltic concrete wearing surface without first bringing the gravel base to a regular surface of the same cross-section as desired for the finished pavement.

Asphaltic Concrete Pavement Built by the Murray Construction Co. in Coahoma County, Mississippi.

To accomplish this result two methods were used, depending on the condition of the gravel base. Under the first method the gravel road was brought to the proper cross-section by filling the holes with new gravel, preferably of the same kind of which the road was built. As most of the holes were shallow, it was impossible to secure a bond between the thin layer of the new gravel and the compact surface of the old gravel. This condition was met and properly taken care of as follows: The old gravel was cleaned of all foreign material and then scarified to a depth of about 2 in., care being taken not to break through to the sub-grade at any point. To this was added a sufficient quantity of new gravel to bring the surface to the proper crass-section, and then the whole was thoroughly rolled. Any holes or irregularities which developed under rolling were immediately filled with additional gravel and the entire surface rolled until it was thoroughly bound and conformed to the regular cross-section. All new gravel which was used was small gravel screenings, and all large stones which were loosened by the scarifier were

Heavy Traffic Over Asphaltic Concrete Pavement in Coahoma County, Mississippi.

[illegible]

[illegible] results were obtained.

[illegible] of holes rather than general wear of the entire surface. On [illegible] method the old gravel surface was cleaned of all foreign material and swept until it was free from all loose gravel and [illegible] section by adding clean gravel or broken stone, mixed with a small quantity of asphaltic cement. The entire surface was taken. Afterwards, the whole was rolled and new material added where needed, until it conformed to the required cross-section and was thoroughly compacted and bonded. This method was used on some roads, but it is doubtful if it would be economical where the old gravel was worn to a considerable extent.

In either method, it is desired to have a well bonded and compact base, but at the same time, the surface should be left as rough as possible to insure a bond between the base and the wearing surface.

As this type of construction is practically in its infancy it would not be wise to draw any definite conclusion as to conditions under which each method should be used or to make any definite statements as to the most economical method. However, it is safe to say that in cases where the road is very badly worn, the first method is practically the only economical solution.

Wearing Surface.—After the gravel base had been brought to the proper cross-section and thoroughly prepared, the wearing surface was applied. Great care was taken to keep the base clean and free from all foreign matter, and the roller was used again ahead of the wearing surface to insure a well-bonded base. It was also important that the base be thoroughly dry and warm. If the base is damp, the application of the asphaltic concrete at a high temperature will create steam pockets which will prevent a perfect bond between the base and the wearing surface. If the base is cold the asphaltic concrete will be cooled too suddenly, before it can be properly placed.

To insure the success of the pavement, no work was done when the weather conditions were not highly favorable.

The finished wearing surface was built 14 ft. wide, 2 in. thick, and is composed of crushed stone, sand, and asphalt cement, all of which were required to pass the specifications.

Cost of Wearing Surface.—The cost of the asphaltic concrete wearing surface was $1.73½ per square yard for finished pavement. The cost of the preparation of the base varied materially, with the condition of the old gravel road, the amount of new material to be added and the distance which this material was hauled.

It should be stated that the price per square yard for wearing surface included all items of preparation except furnishing and handling new material. The cost for this will have to be computed for each section of road, hence cost data for any particular work would be of no value. However, the total cost of this type of construction should not exceed $2 per square yard of road improved. It will be readily seen that if this construction proves successful it may be used for new construction as well as resurfacing old gravel roads [illegible] ng gravel base would be considerable [illegible] te base which has been used [illegible]

[illegible] the work done [illegible] truction. However, [illegible] roads has proved [illegible]

Mechanical Apparatus Used in Snow Removal Work

In fighting the blizzard of 1920 almost every conceivable type of mechanical apparatus was used. Auto trucks with plows attached in front were successful in some cities. Tractors were employed to push plows or drag graders, scrapers and scarifiers. Rotary plows attached to tractors or to electric street cars proved successful in clearing portions of the street for traffic. In New York a flame thrower was devised and attached to the front of a motor truck. Locomotive cranes with huge buckets and also steam shovels were found effective in Boston and New York. Snow melters were tried in other cities. The following brief descriptons of the various types of mechanical apparatus used are taken from a report, "Snow Removal in American Cities," of the New York State Bureau of Municipal Information, issued on Nov. 20:

Friedman Snow Tank.—During last winter successful demonstrations were made in the streets of New York City, of the operation by two men, of a machine handling snow at the rate of 50 cu. yd. per minute, or ice at the rate of 25 yd. per minute, clearing a path 9½ ft. wide at the rate of 8 miles per hour for a 6-in. snowfall and delivering the snow or ice continuously to trucks or cars alongside or depositing it in piles, thus eliminating a large amount of hand labor and providing for a rapid opening of street for traffic obstructed by snow.

The machine, called a Friedman snow tank, is 26 ft. long, 9½ ft. wide and 12½ ft. high, weighing 22 tons. It has a steel frame tank mounted on a Christie 4-wheel drive truck with a special frame. Over the rear wheels of the truck is mounted a 150-H.P., 6-cylinder Sterling marine engine 5½-in. bore and 6¾-in. stroke which is started electrically from the rear platform. This engine operates an inclined conveyor having two parallel sets of steel buckets with heavy cutting edges mounted on endless chains and acting as shovels that cut and scoop up the snow and ice and elevate it, in a closed box, into the receiving hopper as the machine advances under its own power like an ordinary automobile truck. The contents of the hopper can be discharged continuously, clear of one side of the machines by a transverse conveyor thus forming a bank alongside the cleared space, or it can be discharged intermittently by opening the side door in the hopper and operating a lever that empties the contents in a separate heap on the ground or delivers it to the car or truck alongside. When not excavating, the machine has a maximum speed of 10 miles per hour, with four speeds ahead and one speed reverse. It can excavate at the rate of 8 miles per hour in snow 6 in. deep to 2 miles an hour in snow 24 in. deep, loading flat cars at the rate of 25 or 50 yd. per hour according to the consistency of the material handled. An 8-yd. truck can be loaded in from 1 to 1½ minutes.

The machine can be operated continuously day and night except for reasonable allowance of say two hours per diem for oiling, cleaning, fuel supply, change of shifts, etc., thus affording 22 working hours in which time it is capable of loading 1,300 8-yd. trucks. It is operated by 2 men, the truck driver and the mechanic who stands on the rear platform and operates the motor underneath the levers controlling the loading slide. In a speed demonstration, held Friday, March 19, for the New York City authorities, four 5-ton trucks were filled with ice in less than three minutes.

Allowing an extra man, three in all, for the operation of the machine and assuming it to require 5 gal. of gas and oil per hour with $25 per day for wear and tear and $50 per day for overhead, the total cost of excavating and loading at the rate of one truck load per minute is $0.20 as compared with $2.66 for loading with an 8-man gang in 20 minutes. Adding to this $1 for the average cost of an auto truck carting the snow and returning in 15 minutes, the cost of the machine work is $1.20 and by hand is $3.66. The total cost to the city, allowing for expansion of snow in the trucks, and for piling, loading and carting, is estimated at $6.12 for 8 cu. yd. for hand work, while the corresponding cost for machine work is only 64 ct., thus affecting, according to the promoter's figures, a saving of $5.48 for large truck loads or about $.68 per yard of snow and ice. They also estimate that a fleet of 50 of these machines would clean the streets of New York in from 1 to 3 days, depending on the size of the snow fall, and would require a large number of automobile trucks systematically operated to be in constant attendance on each machine and to move uninterrupted back and forth between it and the dumping grounds.

Steam Shovels.—Steam shovels gave effective service in several eastern cities. In Springfield, Mass., Keystone traction steam shovels, used on snow removal work, were run in 12-hour shifts right through the 24 hours. The same type shovel also was used in New York City. In the latter city the Anorac Engineering & Contracting Corporation, which with other organizations was impressed into the service of the city in its snow removal emergency, moved its Keystone grader from an uptown excavation job into the business district and placed it at work loading snow into trucks. The first day it was impossible to get an adequate supply of fuel for the grader, the hauling conditions were so bad. It also was impossible to keep the grader supplied with trucks fast enough to keep it busy, so that the first day it was idle about half the time, but nevertheless removed about 272 yd. (city measurement) of snow. Traveling conditions did not improve the second day and while the number of trucks was increased the grader still was not working to capacity. As the snow was gradually removed and hauling conditions improved, the output of the grader was correspondingly increased, until Feb. 14, when a maximum output of 439 yd. (city measurement) was reached. The measurement by the city of trucks for the snow removal allowed what is called a heap measurement of 6 ft. over the top area of the truck. Most of the trucks have been filled at least 2 ft. over the top area, for which no allowance is made in this measurement by the city. The contractors consider that the grader took the place of at least 50 laborers during this entire work for snow removal, even considering the time lost through unforeseen difficulties.

Rotary Snow Plow.—A power operated rotary snow plow hauled by horses is a new development in snow removing machinery for cities. This machine is being used on some streets in Canadian cities with satisfactory results. A rotary plow conisting of four blades, 22 in. in diameter, driven by a 60-H.P. gasoline engine, is mounted on sleds and drawn by horses. The cutters or blades are driven at a speed of 500 revolutions per minute, and discharge the snow through deflecting hoods on one or both sides of the machine, according as desired. These deflectors are adjustable to enable the snow to be thrown either 3 or 4 ft. or 40 to 50 ft.; it cuts a path 5½ ft. wide. Four or six horses are used to draw the machine but the machine can also be attached to a motor truck. It will work in snow up to 6 ft. deep and leaves a bed of 6 in. of snow for sleigh traffic. In Westmount and Outremount, where these are being used, it was estimated that the machines could remove snow for a cut 5 ft. wide, 4 ft. deep, a mile long, for $20.79. In three days the machine cleared a 10-ft. path of snow, 21 in. deep for a distance of 6,775 ft. at a cost of $.072 per linear yard. or $.037 cents per cubic yard; this included fixed charges for repairs, interest and depreciation. Shoveling the same amount of snow by hand cost $.237 per linear yard or 12 ct. per cubic yard. Such a machine appears to be very useful for opening up traffic where there is sufficient room in the street to permit the snow to remain adjacent; but where the snow must be removed the expense would be greatly increased.

Snow Melting.—Various methods have been tried for melting snow. This has included the use of electricity, steam, hot water, oil burners and flame throwers. According to E. P. Folwell, removal by melting is theoretically practical at a cost of 29 or 30 ct. per cubic yard of snow. But according to the reports from the few cities which have tried this it has not been successful. Mr. J. F. Fetherston by actual tests showed that 1 lb. of anthracite coal would melt a little over 1 cu. ft. of loose snow at 29¼ ct. per cubic yard as compared with 24 ct. for truck hauling and 12 ct. by the use of truck and sewers. It would require 70 h.p. boilers working 24 hours a day for 6 days to remove a 6-in. snow storm. If electricity is used it requires about 35 k.w.h. per cubic foot to melt snow which weighs 35 lb. per cubic foot of an equivalent of 1 k.w.h. for each 25 lb. of snow.

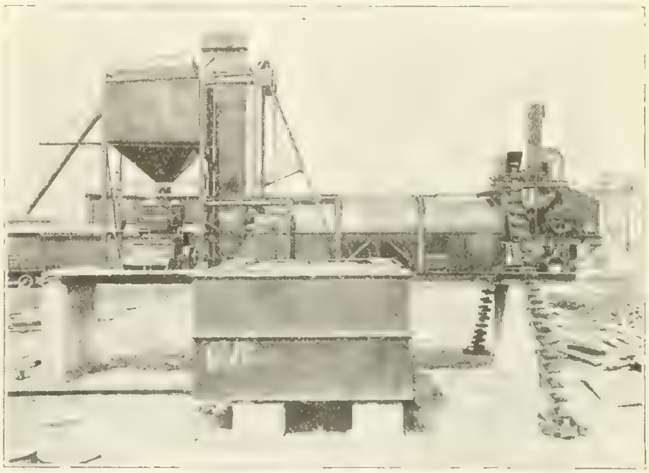
Oil Burning Snow Melter.—The heavy snowfall in eastern cities resulted in the trying out of several new types of snow removal apparatus. One of these consisted of an oil burning flame projector. This device was invented by L. V. Stevens, a Canadian engineer, and has been used on the Canadian Pacific R. R. The truck carries an 1,800-gal. tank of crude oil and travels at the rate of 5 miles per hour. The device throws an incandescent flame some 10 ft. ahead. The oil and air are both forced ahead under compression through a mixer or carburetter, in a manner similar to the practices established in the case of blast furnaces and oil burning locomotives.

Snow Melting Machine Used in Finnish Cities.—A snow melting machine, which is stated to have effected a 60 per cent reduction in the cost of snow removal from streets, is used by the city of Helsingfors, Finland. The machine is described as follows in a recent daily U. S. Commerce Report:

"The melting capacity of the machine is 26 or more cubic yards per hour, depending upon the size of the machine and the kind of fuel used. Cheap fuel, such as wood, coke, coal, kerosene and crude oil, may be used. The smallest apparatus, weighing 500 lb. and requiring four men to keep it supplied with snow and fuel, uses, when fired with coke, 200 lb. of fuel and melts 32 cu. yd. of snow per hour. The machine utilizes 90 per cent of the heat developed. The apparatus consists of an iron furnace, water-jacketed all around; a snow receiver, or hopper; surrounding the upper part of the furnace a system of ducts by means of which the water from the melting snow is again forced into the snow, thus increasing the melting, and a high-pressure fan driven by a small electric motor for creating a strong artificial draft and driving the heat developed out through the snow. The cooling of the furnace walls is accomplished by leading the snow water through the water jacket from which it is forced out again through jets into the snow. The apparatus melts snow and ice. The dirt and gravel in the snow is automatically separated from the water outside the machine to avoid clogging drains or gutters. The machine is used in Finland by street cleaning departments, banks, public buildings and property owners."

New 1,850 yd. Iroquois Stationary Asphalt Mixing Plant

A number of new features are embodied in a 1,850-yd. straight line stationary asphalt mixing plant produced by the Iroquois Works of The Barber Asphalt Paving Co. during the last year. The new plant is notable chiefly because of the compact arrangement of all parts on the steel frame. Although designed primarily as a stationary plant, it can be moved from one operation to another with comparative ease. Low first cost, due to the compact arrangement, is an important advantage claimed for this new mixer. Low cost of operation is another feature, since fewer men are required to operate the plant. From the mixer platform one man can reach all levers, and thus control every stage of the loading, mixing and discharging operations. The plant is easy to erect, and the cost of erection is low. With the whole plant on a single frame, all shafts, gears and other units stay in line. There is no need for careful lining up after erection. Either a portable boiler and engine or an electric motor can be used to operate the plant. Fuel oil burners are regular equipment for the heating drum, but coal can be used if desired. The plant is elevated to a height of 8 ft. or more above the ground level, and supported on three columns or piers. Thus ample room for teams or motor truck to load is assured.



1,850 Yd. Straight Line Plant Built for Detroit Asphalt Paving Co.

Road Gravel Hauled 170 Miles by Rail in Side Dump Cars

By utilizing air dump cars for long distance hauling of road surfacing material the Crittenden-Ozark Road Project in Arkansas was able to keep its work going at a time when highway construction generally was being held up because of the prevailing shortage of gondola and open-top cars

This project covers the improvement of some 50 miles of roads in Crittenden and Poinsett Counties, Arkansas, and requires 287,400 tons of gravel for surfacing. The nearest gravel of the desired quality is at Wittenberg, Mo., 170 miles away, on the Frisco R. R. Ordinarily its delivery would be a mere detail of railroad operation In fact, all arrangements had been made to handle the gravel in the usual way in gondola and open top railroad cars unloaded by crane, when the railroad commission handed down its ruling that open-top railroad cars were needed for carrying coal and must not be used for carrying road material. It became a question of shutting down the road work or finding a substitute for railroad cars and the Morgan Engineering Co., the engineers for the district, chose the latter course.

Gravel Train of Western 20-Yd. Air Dump Cars Discharging Its Load at Stockpile.

It happened at this time that the Federal Government was offering for sale a large number of air dump cars, which had been built for war purposes. Most of them were the "U. S. A." type of Western dump cars, made especially for the War Department by the Western Wheeled Scraper Co. and had never been used, the war ending before they could be shipped across. The District bought 105 of these Government cars and arranged with the Frisco R. R. for their hauling.

The gravel pit is about 30 miles from Chaffee, Mo., a division point on the Frisco Railroad. The cars are loaded by steam shovel at the pit by the pit owners, the Silica Real Estate Co., which has its own shovel and locomotives. The cars are loaded with about 37 tons of material each and taken to Chaffee, the locomotive returning to the pit with a train of empties. From Chaffee there is a direct haul to the road district, over a single railroad division.

Gravel Stockpile [illegible] at Turrell, Ark. Crane at Far End Is Loading Wagons.

The loaded cars usually are run in solid trains of about 30 cars each, for which service the railroad receives more than $50 a car, returning the empties in mixed trains without further charge. A small rental for the use of the cars is paid to the road district, amounting to six-tenths of a cent per mile.

One train a day is operated leaving the pit about 6 o'clock evening and Chaffee about midnight, and arriving at its destination the following morning, usually between 9 and 10 o'clock. The work of switching and dumping takes in the neighborhood of two hours, and then the empties are sent back at the first opportunity. A trip of 170 miles and return, including the time consumed in loading, switching and dumping, is made in three days. During the last week in November, 217 cars were unloaded. Every one of these dump cars made two round trips, and some of them made three.

The Industrial Track Construction Co. of St. Louis, which had been building various unloading tracks for the district, entered into a contract to maintain the tracks at three locations and unload the dump cars, for 20 ct. a ton of material. The three locations under this contract are two at Turrell and one at Menasha. At the present writing, there are 35,000 more tons of gravel to be unloaded under this contract, after which stock-piles at other locations will be established, the work of accumulation continuing through the winter.

Several methods have been tried of forming the storage piles. At the start the Morgan Engineering Co. undertook to dump from a permanent track at Clarkdale and then lift the material by crane to a stock pile. After the unloading was let by contract, the pile at first was formed in this way: A fill about 10 ft. high was made by jacking up the track and working the dumped material beneath. The fill then was extended in the usual way, across the full width of the proposed stock pile. Another fill was thrown up there and widened back, and so on. This method has been abandoned and now the fill is built up to the full height desired, by jacking up the track, before widening across. The track is shifted by a gang of about 14 men, under a very competent foreman The far end of the pile is made from 20 to 30 ft. high, or as high as the grade will permit. The locomotive used for switching must be able to push 10 loaded cars up the grade, from 10 to 12 cars being dumped at one time. The storage piles are made about 800 ft. long.

For a time motor trucks were used in hauling from the piles, but the road district is relying on farmers, this winter, the average haul being about 2 miles. There is a maximum haul of 9 miles. At the present time, plenty of teams are offered for this hauling, material being carried in ordinary stick-wagons, loaded by an Erie crane. The district owns 10 of these Erie cranes. In the spring when hauling begins and the haul lengthens, some other means of hauling will have to be found. It will take all of next year to finish the work.

We are indebted to the Earth Mover for the information given above.

State Highway Construction in Pennsylvania in 1920.—The State Highway Department of Pennsylvania during the 1920 construction season has built approximately 410 miles of concrete roadway 18 ft. in width. In 1919 the Pennsylvania Highway Department completed 253 miles of concrete roadway. The maintenance forces of the State Highway Department during 1920 have entirely resurfaced 377 miles of macadam highway and surface treated 1,480 miles of the same type of thoroughfare. In all, the forces of this department maintain 9,503 miles of roadway. Of this mileage 463 miles were in boroughs and on state-aid roads. The department now has under construction approximately 350 miles of concrete, the completion of which will be impossible this year because of the lateness of the season. The Department plans the awarding of contracts for an additional 350 miles of concrete roadway early in 1921 and hopes to be able to complete not less than 600 miles of highway in that year.

Short Course in Highway Engineering at University of Pennsylvania.—The Civil Engineering Department of the University of Pennsylvania has arranged for a brief course in highway engineering, to be given from Jan. 24, to Feb. 11, 1921. The first two weeks of the course will be devoted to intensive instruction in highway engineering, a study of engineering materials, the design and construction of highway structures and the testing of materials used in road construction. The third week of the course will be devoted to a Highway Engineering Conference, at which papers will be given by specialists on all the phases of the design and construction of roads.

Outline of Field to Be Covered By Highway Research*

By A. N. JOHNSON,

Dean of College of Engineering, University of Maryland.

The need for highway research is becoming more and more apparent as our highway program develops. At the recent convention of land-grant colleges held at Springfield, Mass., the subject of highway research was discussed by Mr. Thomas H. MacDonald, Chief of the United States Bureau of Public Roads, who pointed out that one of the largest fields in engineering endeavor during the next 25 years will be the development of our highways and highway transportation. We can not too soon begin these investigations, the results of which should be at hand if economical and scientific progress is to be insured and the largest return made to the public, which has provided so abundantly the funds for this great undertaking. In the discussions before various engineering and technical bodies the lack of needful data by which intelligently to plan and build our highways has repeatedly been remarked.

It is unnecessary to develop further the argument for the need of highway research. Time and space will be more profitably employed in the discussion of highway research itself. It seems proper, therefore, at first to present a general outline of the field to be covered, as a survey of this field should prove helpful. An attempt has therefore been made to present such an outline, which was prepared in September, at the suggestion of Mr. MacDonald, by Charles J. Tilden, professor of engineering mechanics at Yale University, A. T. Goldbeck, testing engineer of the United States Bureau of Roads, and the writer.

The arrangement, as well as the subjects themselves, as here presented for investigation, should be considered more as a general view of the field, rather than a work program. Three general divisions have been named: (1) Investigations affecting road construction and maintenance or road design: (2) investigations affecting the economics of road operation or the use of the road; (3) investigations affecting the economic value of highways to a community.

Under each of these headings are listed the principal factors involved. In turn, a number of subjects have been named as suggestive of those to be included under the various factor headings.

As various work programs are developed and data accumulated a comprehensive outline becomes useful as a guide to disclose whether the work programs are balanced, and if not, to point to those subjects about which more information should be gathered.

The data that may be developed by a given work program, it is evident, may be useful from a number of viewpoints. Thus a traffic study may furnish not only information as to the weights or loads for which to design our highways, it may serve also as an index of the economic value of the roads, and it may also be taken as a basis from which to determine operation costs. In fact, it may be remarked that traffic data underlie much of the information needed to plan and expend wisely for highway improvements.

Little further explanation of the analysis of the highway research field here presented is thought necessary other than to point out that it is to be regarded as tentative. As more study is given to the subject it doubtless will be possible in the near future to present a considerably more detailed outline which will be of greater assistance in outlining work programs.

A TENTATIVE OUTLINE FOR A COMPREHENSIVE PROGRAM OF INVESTIGATION OF PROBLEMS RELATING TO THE DESIGN, OPERATION AND ECONOMIC VALUE OF HIGHWAYS.

Investigation of the effect on road construction and maintenance of:

1. Physical geographic conditions—
    - Climate.
    - Topography.
    - Geology.
2. Subgrade—
    - Character of soil.
    - Moisture.
    - Preparation.
3. Shoulders—
    - Width.
    - Character.
    - Roadside vegetation, trees, etc.
4. Drainage—
    - Bridges, culverts, etc.
5. Type of pavement—
    - Materials.
    - Construction methods.
6. Loads imposed by traffic—
    - Total weight of vehicle.
    - Distribution of weight—
        - On wheels.
        - Sprung and unsprung.
    - Tires.
    - Speed.
    - Wear.
7. Density of traffic—
    - Width of pavement.

Investigations of the effect on the economics of road operation of:

1. Road planning—
    - Financing.
    - Environment—
        - Farms.
        - Mines.
        - Timber lands.
        - Manufacturing centers.
    - Other transportation systems—
        - Railways.
        - Ocean, rivers, canals.
        - Airplane terminals.
    - Roadside treatment.
2. Grade.
3. Surface.
4. Alignment.
5. Traffic movement—
    - Regulations.
    - Grade separations.
6. Highway transport—
    - Vehicles—
        - Weights.
        - Number of units.
    - Routing.
    - Terminals.
    - Financing.
7. Franchises—
    - Street railways—
        - Motor, freight and bus lines.
    - Pipe lines.
    - Conduits.
    - Telegraph and telephone.

Investigations of the effect on the economic value of highways to a community of:

1. Highway traffic—
    - Distribution of traffic—
        - Geographical—
            - Relation to environment.
        - Seasonal—
            - Time of year.
        - Daily—
            - Day of week and month.
        - Hourly—
            - Hourly variation.
    - Character of traffic—
        - Passenger.. { Horse drawn, Motor...... } Weights per vehicle; per wheel; per inch of tread.
        - Freight..... { Horse drawn, Motor...... }
    - Relation to other transportation systems—
        - Rail.
        - Water.
        - Air.
2. Highway costs—
    - Construction costs.
    - Maintenance costs.
    - Operation costs.
3. Financing highway improvements—
    - Methods—
        - Direct taxation.
        - Bond issues.
        - Vehicle taxes and licenses.
        - Tolls.
    - Distribution of cost—
        - To Federal Government—
            - State.
            - County.
            - Local subdivisions.
            - Property owner.

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*From Public Roads.

Cost of Heating and Spreading Road Oil.—The city of Los Angeles, Calif., has been operating an oil heating plant since July, 1918. During the fiscal year ended June 30, 1920, the plant heated and distributed 29,675 bbl. of hot oil, the cost, according to the annual report of John A. Griffin, city engineer, being as follows:

	Per bbl.
Oil F. O. B. tank cars at plant	$2.01
Heating	.36
Spraying on streets	.34
Total	$2.71

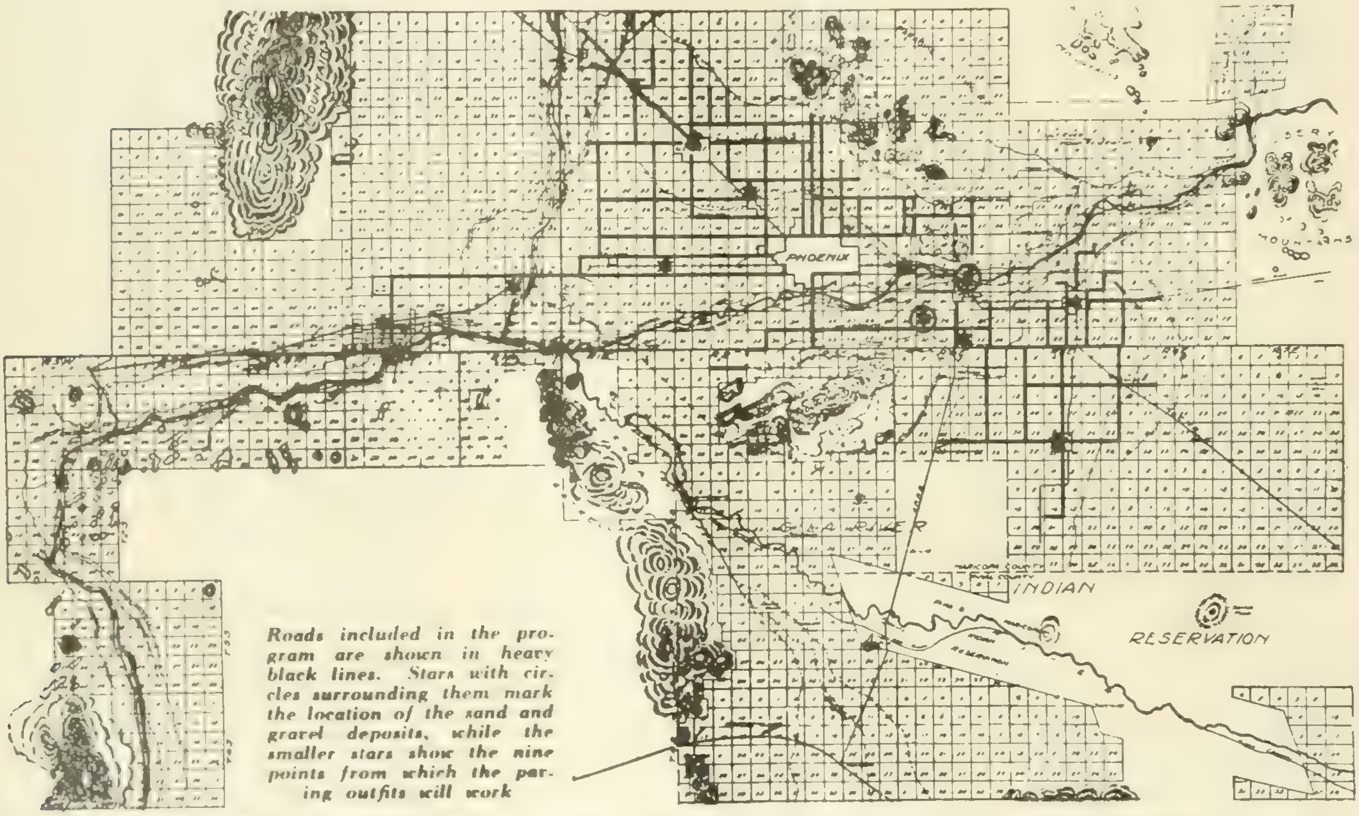
The above is the cost per barrel of 42 gal. spread on the street, or delivered to the department's oil and gravel mixing plants, as the case may be. The heating plant is operated by one man regardless of the quantity of oil handled. It uses steam from the same boiler which serves the asphalt plant with no additional labor expense for producing the steam. For the distribution of this oil the engineering department owns three 5-ton oil spreading trucks, each equipped with a 1000 gal. capacity oil tank and spraying apparatus.

Work Started in 280 Mile Road Contract

Actual concreting on the first stretch of the largest road job ever let to one contractor was begun Nov. 12. The contract calls for the construction of 280 miles of concrete road for Maricopa County, Arizona. Twohy Brothers are the contractors. Two mixers operating from what is known as the Fowler setup will lay the first 41 miles of 16-ft. road before the material trestle and cement shed are moved. One mixer is seven miles from the material plant, the other, two miles.

A second plant has been installed at Chandler, identical with the one at Fowler. The Chandler plant will begin operations about Jan. 1. With the two plants Twohy Bros. expect to build 280 miles of 16-ft. road in three years from eight setups.

Materials are delivered in bottom dump railroad cars. The cars are shunted on top of a material trestle and dumped direct into bunkers under the trestle from which the tip-over batch boxes are loaded by gravity.



Roads included in the program are shown in heavy black lines. Stars with circles surrounding them mark the location of the sand and gravel deposits, while the smaller stars show the nine points from which the paving outfits will work

Map of Maricopa County Road Work, Showing Roads to Be Improved, Location of Sand and Gravel Deposits and Points from Which Paving Outfits Will Work.

Sand and gravel are obtained from Tempe, where Twohy Bros. have installed a washing and screening plant having a capacity of 1,500 yd. per day. Cement is received in bulk and unloaded by means of a Dracco vacuum plant arranged and furnished for this job by the Lakewood Engineering Co. From the time it is loaded into railroad cars, the material does not touch the ground until placed on the road as concrete. The most modern methods are used in every operation. The equipment, representing an investment of nearly $500,000 includes four 14-E Lakewood gasoline pavers with batch transfers, 18 miles of narrow gage road track, 12 6-ton gasoline locomotives, 216 Lakewood road cars complete with batch boxes and cement compartments, 8 double truck cars, 4 finishing machines, and subgraders, 2 bulk cement handling plants each having a capacity of 900 bbl. per day, 8 scarifiers and 1 clamshell bucket.

Wisconsin Road School.—The annual road school and meeting of county highway commissioners of Wisconsin will be held at Madison, Wis., beginning Jan. 31. The meetings will be under the auspices of the State Highway Commission.

Highway Education Committee Appoints C. J. Tilden of Yale, Director

C. J Tilden, professor of engineering mechanics at Yale University, has been granted leave of absence for a year to accept the position of director of the Highway and Highway Transport Education Committee, of which Dr. P. P. Claxton, United States Commissioner of Education, is chairman.

The committee, which was formed last May at the invitation of the Commissioner of Education, in addition to Dr. Claxton, includes Thomas H. McDonald, Chief of the Bureau of Public Roads, United States Department of Agriculture; Col. Mason M. Patrick, Corps of Engineers, U. S. A.; Roy D. Chapin, President of the Hudson Motor Car Co.; W. S. Keller, President of the American Association of State Highway Officials; H. S. Firestone, of the Firestone Tire Co.; Dean Bishop, of the University of Pittsburgh, and Professor Tilden.

The membership of the committee is designed to include representatives of all governmental, educational, and industrial groups interested in the advancement of education in highway and highway transport engineering.

The formation of the committee last May was the first step in a nation-wide undertaking on the part of these groups, and it is expected to lead to better training of larger numbers of highway and highway transport engineers to fill numerous positions which will be available for them in the near future.

The new director will take charge immediately of the work planned by the committee, which includes the compilation of economic, scientific and engineering data relative to highway construction and highway transport, and the distribution of these data to educational institutions. Because of recent development in the science of road construction as it is now practiced, and the still later development of automotive and transport engineering, there are no up-to-date textbooks for use in colleges and technical schools. Several large governmental and industrial agencies have agreed to supply data for such books from their experience.

It is expected that Professor Tilden's work ultimately will lead to the formation of a comprehensive program of education for highway and highway transport engineers which will insure an adequate supply of technically trained young men to fill the ranks of the growing branches of the engineering profession.

Excess Lift as a Factor in Highway Transportation

By ROBERT C. BARNETT,
Economic Engineer, Kansas City, Mo.

One of the important details connected with the general problem of arriving at the economic balance of the factors affecting the cost of highway transportation is that of determining the "economic excess lift" for a particular set of road conditions and the annual tonnage to be transported. As a means for ascertaining this critical excess lift, there is now presented a method which follows the line of thought set up in previous contributions* touching the general problem. Let us first consider those basic conditions which govern the solution.

The movement of a certain annual tonnage over a given highway from point of origin to destination involves an expenditure of a definite amount of energy. This energy is expended in overcoming the tractive resistance of the road surface throughout its length, in lifting the load through a vertical distance, in overcoming the resistance of the air and also the friction of the motor and transmission gearing.

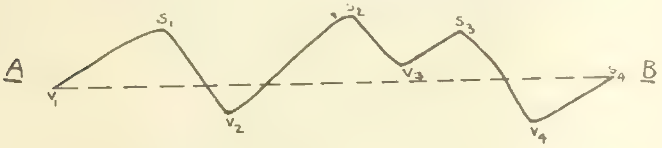


Fig. 1.

The lifting of the load through a vertical distance is necessitated by the difference in altitude of the termini and by the intervening rise and fall of the grade line. As may be readily seen from the diagram, Fig. 1, the total lift is the sum of the several lifts. That is, if s_1, s_2, s_3, etc., represent the elevations of the several summits and if v_1, v_2, v_3, etc., similarly represent the elevations of the several sags, then the total lift that must be given the load during its passage from v_1 to s_4 is given by the expression

$$\text{Total lift} = (s_1 - v_1) + (s_2 - v_2) + (s_3 - v_3) + (s_4 - v_4)$$
$$= s_1 + s_2 + s_3 + s_4 - v_1 - v_2 - v_3 - v_4$$

The difference in altitude between the points A and B is $s_4 - v_1$. As it is generally impracticable to change the elevation of either terminus, the difference in altitude may very properly be considered as fixed. The intervening summits and sags are usually susceptible of modification, so their elevations may be treated as variables for any particular location of the road. It is these with which we are primarily concerned.

If the difference in altitude be subtracted from the total lift, there remains a residual, or excess, lift which may also be treated as a variable in our analysis. By performing the subtraction, we have

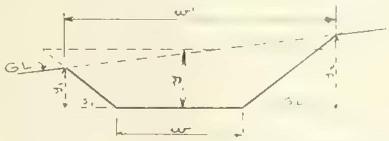


Fig. 2—Cross Section at Summit.

$$\text{Excess Lift} = s_1 + s_2 + s_3 - v_2 - v_3 - v_4$$

As, has been explained in previous articles, the opportunity for utilizing momentum of the moving vehicle is extremely limited; it will not be considered in the present discussion. Hence as new energy must be spent in overcoming this excess lift, its reduction leads to greater economy of operation. However, any reduction in the excess lift means an increased expenditure for grading, assuming the location of the road as fixed, and consequently a larger annual interest charge on construction. To strike a balance between expenditure for power and the interest charge such that the greatest economy will result is the desideratum.

For this purpose, let us suppose that a certain depth of cut of y feet be made at each summit and the excavated material be used to make the fills in the adjoining sags. Also let z_1, z_2, etc., represent the depths of the fills at the respective sags, then the expression for excess lift becomes

$$\text{Excess Lift} = (s_1 - y) + (s_2 - y) + (s_3 - y) - (v_2 + z_2)$$
$$- (v_3 + z_3) - (v_4 + z_1)$$

or

$$XL = \underset{\text{a constant}}{(s_1 + s_2 + s_3)} - 3y - \underset{\text{constant}}{(v_2 + v_3 + v_4)} - \underset{\text{variable}}{(z_2 + z_3 + z_4)}$$
$$= c - 3y - (z_2 + z_3 + z_4)$$

It is to be noted that $(s_1 + s_2 + s_3)$ remains constant for any particular location as also does $(v_2 + v_3 + v_4)$, while $(z_2 + z_3 + z_4)$, being a function of y, is a variable. That is for a given profile, the depth of fill at any sag depends upon the amount of excavated material which may be had from the adjoining summit. In turn this amount of excavation depends upon the depth of cut, y. Hence the next step in our analysis is that of developing an expression for the relation between the excavation at a summit and the cut y, and also one for the relation between the fill z at any sag and y of the adjoining volume of excavation available for such fill. Extreme accuracy is not necessary as only general results are desired.

Two cases will be considered at present.

First Case: Location of highway over new ground admitting of changes in alignment. For this case the ground line for a cross section at a summit will be considered as fairly level, otherwise a lowering of elevation could be readily secured by shifting the alignment instead of making a cut. From Fig. 2, a formula for area of cross section is easily derived.

$$s_1 = ay_1$$
$$s_2 = ay_2$$
$$w' = s_1 + w + s_2$$
$$= ay_1 + ay_2 + w = a(y_1 + y_2) + w$$

but

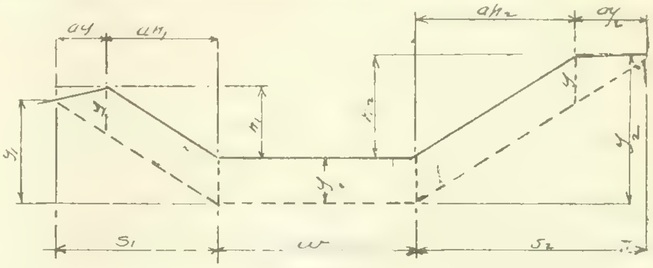


Fig. 3.

$$y = \frac{y_1 + y_2}{2} \text{ approximately}$$

so

$$w' = 2ay + w$$

$$\text{Area} = \frac{(w' + w)}{2}\,y = \frac{(2ay + w + w)y}{2} = ay^2 + wy$$

Second Case: Location of highway follows existing road in which case some preliminary grading may be necessary to widen out the shoulders and provide ditches. Such grading is not dependent upon y and so may be treated as a constant for any particular stretch of road. The area of the cross section which is dependent upon y is determined as follows:

In Fig. 3 let the full line represent the cross section after the preliminary grading has done. Then the area to be considered is that between the full line and the dotted one. This is composed of two triangles, two parallelograms and one rectangle.

$$\text{Area} = \frac{ay^2}{2} + ah_1y + wy + ah_2y + \frac{ay^2}{2} = ay^2 + y(ah_1 + w + ah_2)$$

in which

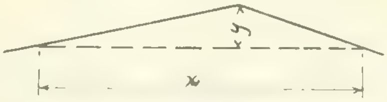


Fig. 4.—Profile at Summit.

$ah_1 + w + ah_2$ = a constant and may be replaced by w″ then

$$\text{Area} = ay^2 + w''y.$$

This equation is of the same form as that for Case 1.

We may next deduce a general expression for the volume of excavation at any summit. Ordinarily the profile of the center line of roadway may be taken as shown in Fig. 4, in which case x varies as y. Occasionally a case will be found where a better approximation would be to vary x as the square root of y. Considering the more usual case, we have

$$x = b_1y$$

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*Engineering and Contracting, Sept. 1, 1920.

b_n being different for different summits. The volume of excavation now becomes

$$V_n = \frac{A_n x}{2} = \frac{Ab_n y}{2}$$

or by substitution

$$V_n = \frac{(ay^2 + wy) b_n y}{2} \quad \text{for Case 1.}$$

or

$$V_n = \frac{(ay^2 + w''y) b_n y}{2} \quad \text{for Case 2.}$$

Total volume $= V_1 + V_2 + V_3 +$ etc. Reducing this to cubic yards, we have

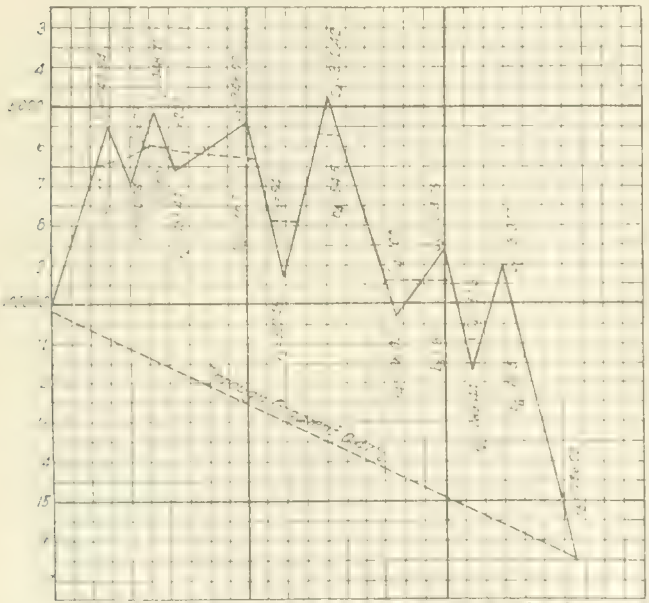
$$V_t = \frac{(ay^3 + wy^2)}{54} (b_1 + b_2 + b_3 + \text{etc.})$$

(For Case 2, change w to w''.)

The cost of making this excavation is readily obtained by multiplying V_t by the unit cost, from which the annual charge for interest may be obtained. Let this annual charge be represented by I_E and let k be the annual charge for 1 cu. yd.; then

$$I_E = kV_t = k(b_1 + b_2 + b_3 + \text{etc.}) \left(\frac{ay^3+wy^2}{54}\right)$$

The cost of providing the additional right of way required by an increase in side slopes is readily obtained from Fig. 2 and Fig. 3. Let L equal the length of the road in feet, then it is seen that



[illegible] Profile of a Portion of the F[illegible] Highway.

Additional area $= 2ayL$.

This reduced to acres becomes

$$\frac{2ayL}{43560} = 0.000046ayL.$$

Letting j equal the annual interest charge per acre, we have for total interest charge for additional right of way the expression

$$I_R = 0.000046jyL.$$

The total annual charge for excavation and right of way now becomes

$$I_E + I_R = \frac{k(ay^3 + wy^2)}{54} \Sigma b + 0.000046jyL.$$

The energy required to lift the load from A to B is equal to the gross weight of the vehicle passing over the road multiplied by the height through which it is lifted. Let T_a = gross annual tonnage and D_a = the difference in altitude of the termini, then the energy required is given by the formula $E_a = T_a(D_a + X_t) = T_aD_a + T_a\{$[illegible] ny [illegible] $(z_2 + z_3 + z_4 + \text{etc.})\}$

It will now be expedient to express z_2, z_3, z_4, etc., in terms of y. Following a similar process as that for finding the area of the cross-section of the excavation at a summit, we have

$$\text{Area for fill} = az^2 + wz, \text{ or } az^2 + w''z.$$

Let x^1 represent the length of this fill, then from the profile it will be seen that $x^1 = c_n z$, c_n being different for different sags. The general expression for the volume of fill at any sag becomes

$$F_n = \frac{(az^2+wz)\, cz}{2} \quad \text{for Case 1.}$$

or

$$F_n = \frac{(az^2 + w''z)\, cz}{2} \quad \text{for Case 2.}$$

Now F_n bears a direct relation to V_n. Allowing for a shrinkage factor f, we have

$$F_n = fV_n$$

or

$$\frac{(az^2 + wz)\, cz}{2} = f\left(\frac{(ay^2 + wy)\, by}{2}\right)$$

This reduces to the form of

$$z^2 = \frac{fby^2(ay + w)}{c\,(az + w)}$$

or

$$z = y\sqrt{\frac{bf}{c}}\sqrt{\frac{(ay + w)}{(az + w)}}$$

In practice, a will range between 1 and 1.5, while w will lie between 25 and 30, and w'' between 40 and 60. For the usual values of y, w or w'' will dominate the value under the second radical; so that the fraction will approximate unity and its square root will be a still closer approximation to unity. We may, therefore, write

$$z = y\sqrt{\frac{bf}{c}}$$

for any fill. Should special conditions be encountered requiring a closer approximation, y may be given an exponent slightly greater than unity such that the desired degree of accuracy may be obtained after a trial or two.

Reverting to our equation for energy and substituting therein the value for z, we have

$$E_a = T_aD_a - T_a\left(ny + yf^{\frac{1}{2}}\Sigma\sqrt{\frac{b}{c}}\right)$$

This energy output per annum for overcoming vertical lift multiplied by its unit cost gives us the annual charge for operation. Letting m represent this unit cost, we have mE_a as the annual charge for energy. This charge added to the previously determined interest charge equals the total charge under consideration. Thus the annual cost becomes

$$C_a = I_E + I_R + mE_a$$

or by substitution

$$C_a = \frac{k(ay^3 + wy^2)}{54} \Sigma b + 0.000046jyL + mT_aD_a$$

$$- mT_a\left(ny + yf^{\frac{1}{2}}\Sigma\sqrt{\frac{b}{c}}\right)$$

For the greatest economy, the annual cost should become a minimum. To obtain this critical value of y, the usual method of placing the first derivative of the function equal to zero is followed.

$$\frac{dC_a}{dy} = k\,\frac{3ay^2 + 2wy}{54}\,\Sigma b + 0.000046jL$$

$$- mT_an - mT_af^{\frac{1}{2}}\Sigma\sqrt{\frac{b}{c}} = 0$$

or

$$3ay^2 + 2wy = \frac{54\left(mT_an + mT_af^{\frac{1}{2}}\Sigma\sqrt{\frac{b}{c}} - 0.000046jL\right)}{k\Sigma b}$$

As the second derivative is positive, this value for y would make the annual cost a minimum. When the known terms are given their proper numerical values for a particular case, this equation for economic cut reduces to a simple quadratic easy of solution.

As an illustration of the application of the foregoing analysis, an example from actual practice is here presented. The road selected is a short stretch of the Fort to Fort Highway in Wyandotte County, Kansas. A condensed profile is shown in Fig. 5. The road follows a former highway location requiring a small amount of grading, hence the conditions of Case 2 apply. The numerical values to be substituted in the equation for economic cut are as follows:

$a = 1.5$ the usual $1\frac{1}{2}$ to 1 slope
$w'' = 50$
$m = 0.00014$
$T_a = 300000$
$n = 6$
$f = 0.8 \quad \sqrt{f} = 0.9$ nearly
$L = 13300$ feet
$j = 12$, 6 per cent interest on $200 per acre land
$k = 0.042$, 6 per cent interest on the unit cost of grading taken at 70 cent per cubic yard.

From Fig. 5 we have

$b_1 = 77.0$	$c_1 = 77$	$\sqrt{\frac{b_1}{c_1}} = 1.00$
$b_2 = 68.0$	$c_2 = 200$	$\sqrt{\frac{b_2}{c_2}} = 0.58$
$b_3 = 166.7$	$c_3 = 54$	$\sqrt{\frac{b_3}{c_3}} = 1.76$
$b_4 = 54.5$	$c_4 = 100$	$\sqrt{\frac{b_4}{c_4}} = 0.74$
$b_5 = 91.0$	$c_5 = 51.2$	$\sqrt{\frac{b_5}{c_5}} = 0.95$
$b_6 = 62.5$		$\sqrt{\frac{b_6}{c}} = 1.10$
$\Sigma b = 519.7$		$\Sigma\sqrt{\frac{b}{c}} = 6.13$

For making the fill at v_4, material is assumed to be taken from s_4 and s_5.

The following considerations led to the adoption of 0.00014 for an average value of m. The unit cost of energy delivered to the driving wheels of the vehicle is made up of the cost items of gasoline, oil, grease, waste, maintenance of power plant (all of which bear a direct relation to the amount of mechanical work done), and the driver's salary. Information along this line is not yet plentiful nor is it standardized, so we must accept a tentative value for the present. The supporting data are these:

For a day's run of 50 miles on an average country road	
6 gal. of gasoline at 25 ct.	$1.50
Oil, grease and waste 20 per cent of gasoline cost	.30
Maintenance 50 per cent of gasoline cost	.75
Driver's salary, per day	5.00
	*$7.55

*Or 15 ct. per mile.

The work done by a three-ton truck against a road resistance of 70 lbs. per ton of gross load in traveling over the mile is (gross load 6 tons)

$$6 \times 70 \times 5{,}280 = 2{,}217{,}600 \text{ foot pounds.}$$

Since the traffic is measured in tons, it will be expedient to reduce the work per mile to foot-tons by dividing by 2,000. We thus have for the unit cost of energy 0.15 ÷ 1,108.8 = 0.000135, or say 0.00014.

Substituting these numerical values for the known quantities in the equation, we have

$$4.5y^2 + 100y = \frac{54\,(.00014 \times 300000 \times 6 + .00014 \times 300000 \times 0.8 \times 6.13 - .000046 \times 12 \times 13300)}{.042 \times 519.7}$$

or

$$4.5y^2 + 100y = 1{,}180.$$

Solving this quadratic, we find that the economic cut for the conditions set forth is

$$y = 8.5 \text{ feet.}$$

By substituting this value for y in the formula for z_n, we may compute the fills for the several sags.

$$z_n = 0.9 \times 8.5\sqrt{\frac{b_n}{c_n}} = 7.65\sqrt{\frac{b_n}{c_n}}$$

$z_1 = 7.6$
$z_2 = 4.4$
$z_3 = 1.4$
$z_4 = 9.2$
$z_5 = 7.3$

The profile corresponding to these values for y and z is indicated by the dotted line in Fig. 6. The excess lift has been reduced from 166 ft. to 77 ft. This saving of 89 ft. of lift is equivalent, from the operating standpoint, to the elimination of 5,874 ft. of distance, or 44 per cent of the actual length of this stretch of roadway.

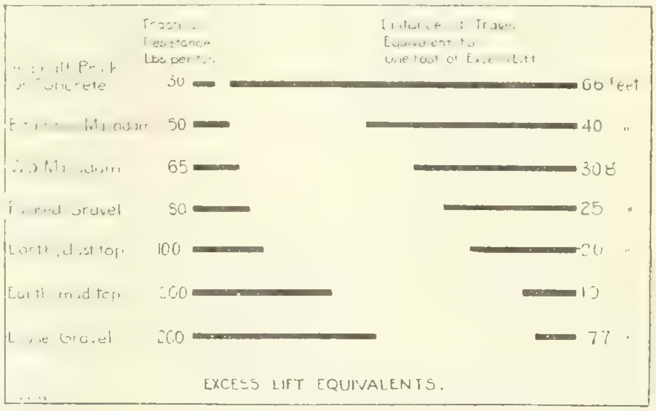


Fig. 6.

This illustration serves to show the importance of excess lift as a factor in economic transportation. It also indicates the need for more careful study and analysis of proposed alignments and grades from the viewpoint of the users of the roads. The case selected is only one of many that have come to the writer's notice. Our main traveled highways furnish many instances similar to the one cited, hence the need for centering attention on this factor of excess lift. To this end Fig. 6 is presented for ready assimilation. It shows the distance that a load may be moved over different roads using the same amount of energy that would be required to lift it 1 ft. vertically. It is to be noted that the better class of pavements have higher equivalents, hence the greater importance of reducing excess lift before such road surfaces are constructed.

Cost of Maintenance and Repair of Oiled and Gravel Streets at Los Angeles

The work of sprinkling, cleaning, repairing and reconstruction of oiled and gravel streets at Los Angeles, Calif., is in charge of a Street Maintenance Department of which T. W. Moore is superintendent. The following account of the work done during the fiscal year ended June 30 last, is abstracted from the annual report of John A. Griffin:

Sprinkling has been reduced considerably on account of nearly all of the streets having a good oiled surface. Additional sprinkling would tend to cause the streets to wear out more rapidly and would not be of advantage from a dust laying standpoint. Until April 1, 1920, five Moreland sprinkling trucks were hired by contract. At the present time, three trucks only are being used. Sprinkling by this method costs $0.7369 per mile. Additional sprinkling service is given during the summer months with Ford tractors. This vehicle is constructed by using a flushing wagon with sprinkling heads, instead of flushing nozzles, and a Ford runabout with a Woodward transmission to afford the proper gear ratio. Sprinkling with the Ford tractors costs $0.7111 per mile.

Gutter cleaning is a part of the routine of district maintenance and each foreman arranges so that a part of his men work over the district systematically, so that each street received the proper share of cleaning. Streets in closely built-in neighborhoods receive more cleaning than in outlying sections. During the year 3640.65 miles of gutters were cleaned at a cost of $29.97 per mile.

Repairs to streets are made by two methods, patching with a mixture of oil and gravel prepared at the city plants, or re-surfacing, which consists of rooting, discing, grading, rolling and oiling. The patch work is undertaken where small or isolated holes appear in the surface, and is very satisfactory as a temporary repair.

The method used in re-surfacing is to plow a roadway with a rooting machine having from three to five points, according to the size of the roller. The plowed street is then thorougly disced. After a heavy application of water the street is graded, rolled, re-graded and re-rolled. The roadway is then ready for oil, which is applied by pressure spray at a temperature between 300 and 400° F., this application being approximately ½ gal. per square yard. The oil is covered with rock screenings to a depth of about ½ in. In the past year resurfacing work has been completed as follows:

	Per mile.
Rooting, 60.98 miles	$ 147.60
Discing, 60.98 miles	141.52
Rolling, 60.98 miles	227.35
Grading, 60.98 miles	136.71
Wetting surface, 60.98 miles	56.63
Total	$ 709.81
Oiling, 86.50 miles	536.61
Crushed rock for cover	546.45
Total	$1,792.87

How New York City Will Use Mechanical Apparatus for Snow Removal

New York City has purchased a large amount of mechanical apparatus for use in removing snow from the streets. This equipment includes 212 5-ton gasoline trucks, 100 2-ton trucks, 150 4-wheeled plows, 300 auto front plows, 150 tractors of the caterpillar type (100 small size, not less than 3,800 lb. and 50 not less than 8,000 lb.), three wrecking cars equipped with cranes, four ¾-ton delivery trucks for delivering supplies, and one mechanical snow loader (Friedman machine). The general plan of operating these tractors and 5-ton trucks is outlined as follows in a report of the New York State Bureau of Municipal Information on "Snow Removal in American Cities."

As soon as a snow fall starts and the Commissioner is convinced—after consulting with the Weather Bureau Officials—that it will be a continued storm, he will issue orders to have the tractors and trucks begin work. The plows will be attached to the trucks at the various garages, and the police, fire and street cleaning operators who are assigned to this work will immediately report for duty and proceed at once to the points where they are to plow.

The scheme, as outlined, is to have plows in teams of two clean a width of 20 ft. of roadway for a distance of 3 lineal miles in one hour and to continue working over such a route after the snow has ceased falling. The average rate of snow fall is ½ in. per hour and the motor-driven plows operating at the rate of 3 miles an hour, will cover the entire area every 2 hours, constantly plowing 1 in. of snow on each trip up and down the assigned area.

With 150 tractors and 250 5-ton trucks operating, all of which will have snow plows attached, starting at 200 different points and covering 3 lineal miles, cleaning 20 ft. of roadway, it will be noted that the department will—with its own equipment—have plowed at the cessation of snow fall in each storm 600 miles of roadway in the important sections of the city, 70 per cent of which will be in the Borough of Manhattan so that there will be no interruption of traffic such as practically paralyzed the trucking business last year and incurred the loss of millions of dollars.

This force will be augmented by the hiring of auto trucks to which department snow plows will be attached and it is estimated that 100 of these will be engaged in working in the same manner as the Department trucks and tractors covering an additional 150 miles of roadway. It is intended that this total force will be operated within one hour after the call has been issued by the Commissioner, so that if the storm is in progress 1 hour and it is decided to call out the forces, all the equipment will be in motion within 2 hours after the storm starts, or in other words, the full force of motor trucks and tractors will be operating when the snow shall have reached a depth of 1 in.

The first point in the work of snow removal is to keep traffic moving. This will be accomplished by throwing the snow from the center to the sides of the roadway. The second point is to have the snow removed as quickly as possible after it is thrown to the sides. For this purpose it is intended to utilize the 100 2-ton department trucks and the department force of carts, approximately 500 in number, on the first day of each storm to haul the snow to the most convenient disposal points, such as sewers and water front dumps.

During the progress of a storm, the laborers will be assigned to work at the same time that the call is issued for the plows to start out and they will pile the snow just as soon as it is thrown to the side of the roadway by the plows. This will obviate delay as formerly occurred while waiting for the contractors' forces to begin work, which was usually delayed until the following day.

It is purposed to utilize the plows attached to the tractors to push snow from the roadways to the sewer manholes wherever such are available, after they stop plowing, which means that 150 tractors will be pushing snow on all streets where sewers are available and in this way great quantities will be removed quickly.

The plans also provide for registration of the emergency men in advance of the winter season in order to have an available snow fighting force of laborers report at the 103 section stations throughout the three boroughs, at which places they will be equipped with picks, shovels and pan scrapers; and under the direction of squad leaders they will be assigned to certain routes for sewering or piling the snow, depending upon the type of sewer adjacent to the various points at which they are assigned to work.

Highway Conference at Philadelphia.—Officials of the highway departments of Pennsylvania, Delaware, New Jersey and Maryland, and of the Bureau of Surveys, city of Philadelphia, together with the Bureau of Public Roads, Washington, will co-operate in a highway engineering conference to be held in Philadelphia, Feb. 14 to Feb. 19, 1921. This conference will be under the auspices of the Department of Civil Engineering, University of Pennsylvania, of which the Professor in charge is Milo S. Ketchum. The Advisory Committee is composed of Colonel W. D. Uhler, Chief Engineer of the Pennsylvania State Highway Department; Charles M. Upham, Delaware Highway Department; John M. Mackall, Maryland State Roads Commission; T. J. Wasser, New Jersey Highway Commission, and George S. Webster, Chief of the Bureau of Surveys, Philadelphia.

Personals

F. W. Austin has been appointed city engineer for Chanute, Kans., effective Jan. 1, 1921.

Hubbard, Harris & Rowell, Inc., Bridgeport, Conn., has taken over the consulting engineering practice formerly carried on by the firm of Hubbard & Harris, Inc.

J. E. Huber, district engineer with Illinois Department of Public Works and Buildings, Division of Highways, since 1913, has resigned to accept a postion with the Western Wheeled Scraper Co., at Aurora, Ill.

Industrial Notes

The Chicago Pneumatic Tool Co. announces the resignation of H. L. Dean, formerly manager of the compressor and engine sales division.

The Holt Manufacturing Co., Stockton, Calif., and Peoria, Ill., announces the election of Thomas F. Baxter, president of the corporation.

The Chicago Pneumatic Tool Co. announces the appointment of J. F. Huvane as eastern manager of compressor and engine sales, with headquarters at 6 E. 44th St., New York, and G. C. Vanden-Boom as western manager of compressor and engine sales, with headquarters at 300 N. Michigan Blvd., Chicago.

Clarence H. Kennedy, sales manager Kennedy Valve Mfg. Co., Elmira, N. Y., is recovering from painful injuries received in an automobile accident at Elmira on Dec. 11. As he was driving his machine to the plant, the vehicle skidded on the icy pavement and collided with a street car. He was taken from the wreckage unconscious and first reports stated that his skull had been fractured. When he regained consciousness, this was found to be not the case. Later information is to the effect that he may not be able to resume his duties for two or three months.

The Pawling & Harnischfeger Co., Milwaukee, Wis., held its fourth annual Xmas party of its employes on Dec. 21, at Riverview Roller Rink. Because of the fact that the majority of the 1,100 employes have been connected with P. & H. for long periods of service, ranging from 10 to 20 years, this was an unusually happy Yuletide affair. The program included a concert by the P. & H. Employes Band, an address by the president, Mr. Henry Harnischfeger, and choral singing of Xmas hymns. Gifts and candy were distributed to the children. A dance program concluded the evening.

The Detroit Steel Products Co. has increased its capitalization to $5,250,000.00, and declared a common stock dividend of 300 per cent, thus distributing a portion of the company's surplus, which has accumulated during the last ten years. The management believes the time is opportune to strike an optimistic note, and at the same time to afford the stockholders control of their surplus. President J. G. Rumney states that the Detroit Steel Products Co.'s branch offices and agencies, located in every section of the United States, support this feeling of optimism, as shown in recent reports of conditions in their respective environments. The foreign representatives also report improved conditions.

Waterworks and Hydraulics Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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California Commission Advises San Francisco to Buy Water Co. Plant

The California Railroad Commission has just completed a valuation of the property of the Spring Valley Water Co. and has recommended the purchase of the plant by the city of San Francisco. The plant is appraised at $37,000,000. The population of the city, according to the U. S. Census, was 507,000, but the Commission says:

> The completion of the Calveras reservoir will make immediately an additional supply of water sufficient to take care of the present urgent needs of the city. It is estimated that this addition to the Spring Valley plant will be sufficient to meet the demands of the city until the completion of the Hetch-Hetchy system and supply the needs of a population in excess of 700,000.

The appraisal was based on "average prices for a six-year period from 1914 to 1920, a time which is considered a reasonable construction period for the property," and accrued depreciation was deducted. An allowance was made for the value of water rights and reservoir sites, also for the value of the franchises and the business.

The city is building a reservoir in the Hetch-Hetchy Valley, and has contemplated paralleling the existing distribution system of the Spring Valley Water Co. The Commission wisely councils the city against duplicating the company's plant.

"Theoretically," says the Commission, "it may seem possible to duplicate the water distribution system within the city limits, but such a duplication is practically an impossibility." Continuing, the Commission says:

"Not only is this true for the reason that, with the present system in place, the cost would be very large (much larger than the total of any reproduction cost estimate of the Spring Valley distributing system), but the legal complications, the delay and time required in the completion of a duplication system, and the technical difficulty involved, also would have to be considered."

Making reference to the general destruction of the streets of the city and the interference with traffic, the Commission says that such a duplication would be a very serious undertaking.

"The waste resulting from such duplication," declares the Commission, "would be, in every sense of the word, unjustifiable." The Commission then says:

"The matter of the duplication of the distribution system is, however, not the most important or serious one. It is most essential that the city, if it owns its source of water supply, be also in ownership and control of storage and general distribution reservoirs in the close neighborhood of the city. Such reservoirs will be required for the storage and distribution of water from Hetch-Hetchy. The only suitable reservoirs actually in existence, together with potential reservoir sites, are the property of the Spring Valley Water Company."

"If a condition could be imagined where the city could duplicate the Spring Valley distributing system, could find the necessary reservoir sites sufficiently close to the city and did bring Hetch-Hetchy water into San Francisco," says the Commission, "there would then be two competing water systems serving San Francisco consumers. Even if city water were available in San Francisco there is no legal power to compel this continuance of service by Spring Valley Water Company to consumers. This would result in wasteful competition and higher cost to the entire community." The Commission further says in this connection:

"The city would probably maintain the field in the end, but the Spring Valley Water Company could continue service a long time since it probably would be in a position to dispose of available excess water supply in the neighborhood of San Francisco on both sides of the bay. The losses to both parties would progressively increase as the unreasonable and unintelligent struggle continued."

San Francisco is the only great American city that does not own the plant that supplies it with water. Six years ago the citizens voted against the purchase of the private plant. Doubtless it is now realized that mistake was then made. It would be ruinously expensive for the city to compete with the company, even could the city build a new plant as cheaply as it can now acquire the old one. But the probability is that the city could not build a duplicate plant for twice what the existing plant will cost the city, to say nothing of the expense and nuisance involved in tearing up the streets.

Commodity Prices Are Nearing the Bottom

According to the Federal Reserve Board, the wholesale commodity index price for December was 190, or 8.5 per cent lower than for November, as compared with 100 for the year 1913. The index prices of the Federal Reserve Board usually differ but little from those of the Bureau of Labor. Hence if we assume that the Bureau of Labor will also show an index of 190 for December, the average for the year 1920 has been 244, and as follows for each of the 12 months:

January	248
February	249
March	253
April	265
May	272
June	269
July	262
August	250
September	242
October	225
November	207
December	190

It will be observed that each of the last three months shows a drop of about 17 points, or 8 per cent. It is probable that January, February and March will show smaller declines, and that April will mark the end of the general slump in prices. The level will then probably be about 165 or 170. Already farm products have declined to 165, and have shown great resistance to further recession. Metals have declined to 170, and they also seem to have "reached bed rock."

Building materials averaged 274 in November, and will probably decline considerably before spring, possibly 25 per cent from the November level. Building materials dropped 12.5 per cent in November as compared with October, which is indicative of the rapidity with which they are likely to fall to the new plateau of prices. As stated in previous editorials, this new plateau will probably be about 70 per cent above the level for the year 1913, because our per capita money has increased 70 per cent.

A Two Million Acre Irrigation Project

Any engineering project that rivals the Panama Canal in cost may well lay claim to greatness. Such a project is the proposed irrigation of two million acres of the Columbia River Basin in Washington, at an estimated cost of $172 an acre.

Lake Pend Oreille in Idaho and Flathead Lake in Montana are reservoirs that receive the drainage of 25,000 square miles. It is planned to construct 56 miles of main canal, 34 miles of tunnels (one of which will be 16 miles long), and 10,000 miles of laterals. The canals and laterals are to be lined with concrete.

An incidental by-product will be the development of nearly a million horsepower of hydroelectric energy. It is probable that a large part of this power will be used eventually for pumping water from the Columbia River to irrigate an additional great acreage of the rich volcanic ash that forms so large a part of the fertile "Inland Empire." The land in one irrigated district of this valley last year produced nearly $170 gross.

Agricultural Output and Prices

Grain crops in 1920 totaled 5 per cent more bushels than in 1919, and 15 per cent more than the average for the 5-year period of 1914 to 1918. The seven leading grain crops plus the potato crop totaled 6,260,000,000 bu. for 1920; 5,880,000,000 bu. for 1919; and 5,300,000,000 bu. for the average yield in 1914 to 1918. These figures throw some light on the course of the recent rapid decline in the prices of farm products. They should also serve to sober hysterical editorial writers who see in census statistics a solemn warning against "the progressive desertion of the farms."

The truth is that the supply of farm labor has exceeded the demand, largely because labor saving machinery has each year increased the output of the average agricultural worker. The excess supply of farm labor has been attracted to manufacturing centers. Now that there is a temporary business depression, some of this labor will drift back to the farms, and will accept lower wages.

The Secretary of Agriculture is so worried over the drop in prices of farm products that he has lost all sense of proportion. In his annual report he says:

> The farmers are not receiving adequate returns for their efforts. The very foundation of our nation the stability of agriculture—is threatened.

This, of course, is a cry of despair that will not pull the heart strings of city residents who have paid very high prices for farm produce these last five years. Nevertheless, it is unfortunate, not merely for farmers but for all classes of producers, that such violent changes in prices have occurred. The fundamental trouble is to be found in a monetary system that is flexible in the wrong direction, expanding when it should be contracting and contracting where it should be expanding.

Agreement of Gillette's Price Formula with Actual Price Changes

To the Editor: Will you kindly allow me a small space in your columns to point out the close agreement of your formula for price changes, using the modification which I suggested, with the actual price changes in the last few months?

In Scribner's Magazine Mr. Noyes gives the decline in prices as 24¾ per cent, call it 25 per cent, then prices now are 75 per cent of what they were. In your formula consider that bank clearings have declined 15 per cent, deposits (or what is the same thing, loans) have declined 5 per cent, per capita currency declined 5 per cent and productive efficiency has advanced 10 per cent. Then taking per capita currency at $55 at first, and per capita deposits at $300 and dividing this by four and adding it to the $55, we get 130; then the figures representing prices before the decline would be 130 divided by 1.00 and multiplied by the fraction 100 over 100, or final result 130. After the decline currency would be 52, deposits 285, clearings 85 and efficiency 1.10, then the figure representing prices would be 52 plus one-fourth 285 (or 123 in all) multiplied by the fraction 85 over 95 and the whole divided by 1.10. Working this out it gives 110 divided by 1.10 or 100. The ratio of prices after the decline to prices before the decline then would be the ratio of 100 to 130 or 77 per cent compared with the actual ratio of 75 per cent. The percentages given may not be the exact percentages but they are substantially correct and the comparison of 77 with 75 is as good as could be expected.

In justification of taking the increase in efficiency at 10 per cent, the increase in freight car mileage from 22.3 miles a day to 28.6 miles from March to December may be cited.

Nashville, Tenn. JOHN WILKES.

Another Call for Hoover

We note an advertisement of the Harriman National Bank in one of our New York papers, entitled "Hoover," and in which is expressed the desire, with appropriate arguments, to have Hoover act as head of a great corporation supposedly to organize under the Edge Act and to foster our international trade. Much has been said lately about the unprecedented opportunity before the country in its export trade. The American Manufacturers' Export Association recently held an important meeting to discuss the salient features of this opportunity, as constructive legislation now upon the statute books—the Edge Law—permits properly incorporated banks to finance foreign trade, and the commercial and general press has given much publicity to the possibility of entering a field of trade hitherto practically closed to the country and still largely in the hands of British financial interests.

Copper producers, cotton growers, and hundreds of other interested parties are tremendously concerned in the steps our country is taking to stimulate its exports. An Edge Law corporation which would perform this function undoubtedly needs executive ability of the highest standing and the keenest business knowledge, to say nothing of a sound knowledge of international affairs. No wonder the call for Hoover. "Would the South, its warehouses bulging with cotton, object to Hoover? Would the farmer of the West, with its record crops? Would the manufacturer of the East, with his raw materials waiting to be turned into goods? Would the financial expert?" So runs the plea, and concludes, "Who would object to Hoover, and who can offer a better name to bring together the consumers of Europe and the producers of America?"

We had not thought of Hoover in this light, but are forcibly struck with the singular appropriateness of his war record to the task of building up our foreign trade through foreign good will. The executive head of an Edge Law corporation with an international reputation possesses an invaluable asset. We have a suspicion that there are other jobs in store for Hoover which would to an even greater extent call upon his ability, and although, as Secretary of the Interior or Treasury, he would preside over some vital department of our Government, and indirectly be concerned in foreign affairs, his counsel in the deliberations of President-elect Harding's cabinet should exert a pronounced influence in shaping the foreign policy of the nation. Without a definite foreign policy and firm, whole-hearted governmental approval and moral support, an Edge corporation cannot fulfill its mission to the utmost, for the ultimate foundation of success in foreign trade lies in our Government.—Editorial in Engineering and Mining Journal.

Power-Plant Accounting

In too many manufacturing plants the power and heating requirements are considered "non-productive" departments and insufficient attention is given to either economical operation or betterments. Coal is purchased and stored with only the most cursory record of the tally and expenditure. In a modern plant or machine shop a tenpenny nail could not be obtained without the proper requisition passing through the accounting channels, notwithstanding that the cost of this particular record may be greater than the article involved.

Contrast this with the methods of handling fuel. In many cases thousands of tons of coal are purchased, piled in the yard and used for heating and power generation with no check except the invoice and car weights from the coal or railroad company. No record of its distribution or accounting is attempted. A truck could be loaded and large amounts diverted to personal uses with no fear of discovery unless the theft was actually observed, and such instances are not unknown.

This is one of the inherent causes of power-plant wastes and also the reason why so many suggested improvements in operation are received with skepticism. As the management has not the faintest idea where the fuel is being used or how economically, there is no basis by which to judge changes or to ascertain whether a saving is possible. This lack of accounting in large manufacturing plants is more widespread than is generally realized.

Plant operators having no records or methods of demonstrating facts are sadly handicapped when trying to improve conditions. It is a function of the executive to probe the suggestions offered and determine the facts. Complete records in the power plant and a little money spent for proper accounting would not only solve his difficulty, but automatically bring about economy in operation by showing up shortages and departure from standard conditions. In operating results the executive would have a basis of comparison—he would know what to demand when an addition or new plant was to be built and after installation he would be able to check what had been received.

With initial investment averaging from $100 to $150 per kilowatt of generating capacity and coal and labor bills running to extremes, it would seem that the comparatively few dollars required for power-plant accounting would be warranted many times over. If every department received monthly bills for power and heat the same as for raw products and labor, it would create a demand for accurate accounting and in doing so insure more economical results.

The introduction of a few miscellaneous meters, even if they are read regularly, and the compilation of fuel costs monthly or yearly are of little use. Such practice may be likened to maintaining a ledger and neglecting part of the entries on one side or the other. Accounting records should be kept so that at any time the manufactured products, such as steam for heating and processing, hot water and power, can be exactly balanced against all loss and expense, including the cost and quantity of the particular fuel purchased and used.

In charging departments a profit should be added to cover upkeep and betterments. In other words, the power plant should be on a separate basis of its own and made to stand on its own feet. Each finished manufactured product and each department should bear its portion of the expense. Unnecessary use of power by overmotoring and other wastes would be reflected in the cost of the offending departments.—Editorial in Power.

Only Applied Research Produces Profit

A sound theory is always valuable, a correct result of careful research is always an asset; but until translated into useful and used form neither produces any dividends. In no field is this more certain than in chemical industry.

In his recent address, "Thrift in Coal," delivered before the Iron and Steel Institute on Oct. 22, George Otis Smith, stressed this point very effectively. He was speaking of boiler-firing results in a large plant which prided itself on the high-grade fuel burned, about 15,000 B.t.u. per pound. This plant was getting only the equivalent of about 11,000 B.t.u. because of poor operating practice, and it is with full justification that Dr. Smith said of the manager: "That coal user needed expert firemen more than chemists—better practice rather than more theory."

Such a situation might seem at first thought to be an indictment of the chemist. In some cases the defect is chargeable to the research man or the chief of the laboratory, but more frequently it is probably the manager or superintendent who is at fault. Any competent chemist, whether engaged only for the control laboratory work or for original research, is a potential asset. However, his value as an operating asset is only potential until the manager gives him an opportunity, indeed, encouragement, for direct application of laboratory results in the plant.

Teamwork in the relationship between chemist and superintendent or chemist and manager is a first essential. Each has an important element to contribute in the application of the laboratory results. The laboratory data are cold figures without the interpretation of the chemist. But an impossible situation and impractical results may often result if the interpretation is solely upon the basis of laboratory ideas. A sympathetic understanding of the limitations of the laboratory as well as cordial appreciation of its possibilities will do much to vitalize the product of the workers with beaker and test-tube. On the other hand an intelligent study of the practical plant problems by the chemist, combined with tact and patience in seeking to apply laboratory results, is also an essential prerequisite to success.—Editorial in Chemical and Metallurgical Engineering.

Cost of Sewer Construction at Providence, R. I.—The following table from the annual report of M. H. Bronsdon, City Engineer of Providence, R. I., shows the average depth of cut, nature of excavation, and contract cost of labor per foot, on the different sizes of regular sewers built in that city during 1919:

Items.	Average nature of excavation.	Aver. depth of cut. Ft.	Aver. cost per foot.
6 in. pipe in drains to curb line	Sand, dry	10.50	$1.10
6 in. pipe in drains to curb line	Sand and gravel, dry	10.50	1.81
6 in. pipe in drains to curb line	Sand and gravel, wet	10 50	2.25
6 in. pipe in drains to curb line	Hard pan	10.50	1.50
8 in. pipe in basin connections	Sand	8.00	1 00
8 in. pipe in basin connections	Sand and gravel, dry	8.00	1.63
8 in. pipe in basin connections	Sand and gravel, wet	8.00	2.00
8 in. pipe in basin connections	Sand, gravel and boulders	8.00	2.00
8 in. pipe in basin connections	Hard pan	8.00	1.50
8 in. pipe in basin connections	Rock	8.00	2.00
8 in. pipe in sewer	Sand and gravel, dry	11.67	2.00
12 in pipe in sewer	Sand and gravel, dry	12 00	2.81
12 in pipe in sewer	Sand and gravel, wet	12 00	3.50
12 in pipe in sewer	Hard pan	12.00	3.67
12 in pipe in sewer	Rock	12 00	3.75
15 in. pipe in sewer	Hard pan	12.25	3.50
15 in. pipe in sewer	Hard pan and rock	12.25	3.00
16 in. iron pipe sewer	Fine sand, wet	15.00	10.00
16 in. circular brick sewer	Fine sand, wet	10.50	9.00
16 in. circular brick sewer	Fine sand and peat, wet	17.00	14.00
Average cost of building manholes, each			$41.64
Average cost of building catch basins, each			31.53
Average cost of building extra inlets, each			15.63

Propose Codification of Indiana Drainage Laws.—Codification of the drainage laws, a question which has been under consideration for some time in the agricultural districts of the state, has been suggested to Warren T. McCray, Governor-elect. Mr. McCray is said to look with favor on the codification project and the appointments of a commission to undertake the task.

Fair Rates for Water Service and Effect of High Prices Thereon

By DABNEY H. MAURY,
Consulting Engineer, Chicago, Ill.

The present abnormal conditions have, by greatly increasing operating expenses, reduced the net earnings of practically all public utilities, and in this respect water companies have, on the average, suffered at least as much as the rest. The same conditions that apply to water companies apply with equal force to municipally owned water departments, which should be, whether they are or not, operated in accordance with approved business methods, and should charge each taxpayer and each consumer of water his fair proportion of the total reasonable cost of the service.

Basic Principles of Fair Rates.—In order that rates for water service may be fair, these two conditions must obtain:

First: The total yearly receipts from all sources must be sufficient to provide

(a) A fair rate of return on the value of the property used or useful for furnishing the service paid for.

(b) Proper annual contribution for depreciation.

(c) Reasonable operating expenses, including ordinary maintenance and repairs.

(d) Taxes.

Second: Each consumer must pay yearly, for the particular class of service that he receives, only his just proportion of the above annual costs.

To fulfill the second condition above specified, no service of any sort whatever should be furnished free.

It may be said that in practice neither of these two conditions can ever be realized with absolute exactness, and obviously the second is far more difficult to approximate than the first; but these considerations can in no way affect the fundamental principles involved.

Value as Distinguished from Cost.—The law requires that the value found for a public utility property, such as a water works system, should be the fair present value of all of the parts of said property that may be used or useful for the purposes for which it is built or operated.

Value is not cost, and almost invariably cost differs in amount from value, sometimes only slightly, but more often to a great extent.

The value sought by any fair-minded appraiser should be the fair value as between a willing purchaser and a willing seller.

Fair rates should pay a fair return on the fair value.

It follows as a corollary to the last two foregoing axioms that the value of a property for rate-making purposes should be the same as its value for purchase.

In other words, the appraised value, if it be a fair one, should stand this test; it should make no difference financially to the city in which the property is located whether it buys the property at the appraised value, or allows the owner to continue to operate the property, and continues to pay him fair rates for the service.

The higher courts have clearly recognized that value, and not past cost, should be used as the basis of rates.

Past costs, and especially those of the recent past, are of very great assistance in estimating the physical value of a plant. For example, if a plant had just been completed, its actual cost would probably be very close to its physical value. This would rarely be the case if the plant were an old one.

The past costs of old plants are rarely obtainable, and even if they can be obtained, they are almost invariably a very inaccurate measure of their present physical value; for depreciation, appreciation, and the changes in prices of materials and labor, all combine to alter values. Furthermore, in determining investment costs, past deficits in earnings below the fair return, or past profits in excess of the fair return, must be considered in connection with the actual past cost of the physical plant. Again, in computing these past deficits or past excess profits, the value of money itself must be taken into account throughout the various periods of the plant's existence; for what is a fair rate of return when the owners of the property can borrow money at 7 per cent is altogether too low when they cannot get it at even 9 per cent, and vice versa.

To take actual physical past cost as a basis of value, and then to deduct from this past cost the accrued depreciation, without considering appreciation as well, would almost always give a result below either past cost or present value. If no allowance then be made either for past deficits in earnings, or for discount on bonds, or for going value, all of which are just as real and inevitable items as are the costs of the physical parts of the plant, the resulting figure can hardly fail to fall far below the fair value.

The consumer also suffers by this injustice, for when such a valuation is a matter of record, it is almost impossible for a water company to borrow money for extensions, and good service cannot be maintained.

Such methods of arriving at a basis for rates would be especially harsh at the present time, when the average compensation of every rate payer has increased tremendously, and when the price of every other commodity, except water, has risen accordingly. Incidentally it may be stated that, while water is the average man's most vital necessity, the cost of it is his smallest annual item of expense.

The method of determining value by capitalization of net earnings would be ideally simple if one knew in advance that these net earnings would continue unchanged for all time, and that they paid no more nor less than a fair return.

The net earnings cannot be assumed to continue unchanged, for the principal duty of utility commissions is the regulation of rates. Furthermore, if the net earnings are more or less than a fair return, it would be manifestly unjust to base the value of any utility subject to rate regulation on these earnings; for it would be unjust to the rate payers to capitalize excessive earnings, and unjust to the owners of the property to base its value on earnings below what they should be. To determine whether or not the net earnings yield a fair return, it would be necessary first to determine the fair value of the property by some other method. From this it follows that to base the value of a property on the capitalization of its actual net earnings, really means nothing and leads nowhere.

The valuation of public utilities by capitalizing their net earnings is actually prohibited by law in some states.

In the writer's opinion, the fairest and most logical of all methods of determining the value of any property is to find what it would cost to reproduce the property as it exists today, with its existing connected business, and with proper deduction for accrued depreciation in the physical plant.

General Classification of Revenue.—Having once determined the reasonable operating expenses, the fair value of the property, and the fair net rate of return, it is a matter of simple arithmetic to arrive at the gross revenue required.

With this required revenue once determined, the next step is to divide it between the revenue which should be paid for fire service, and that which should be paid for the ordinary uses of water, which latter uses will for brevity be herein referred to as domestic service, there being included under this heading all domestic, industrial, and manufacturing uses.

Practically all water works systems are built for fire protection as well as for domestic service. Manifestly, the first cost and operating expenses of a plant built to supply either domestic service alone, or fire service alone, would be less than those of a plant built to supply both classes of service.

In small cities, a large percentage of the first cost of the water works system can fairly be assumed to have been incurred for fire protection. For example, in cities of about 25,000 population, from 40 to 45 per cent of the first cost of the entire system, exclusive of service pipes, meters and meter settings, would probably be incurred for fire service; so that a corresponding percentage of the interest, depreciation and taxes would be fairly chargeable to fire service.

In a very large city, the percentage of the first cost of the system which would be incurred for fire service would be almost negligible, as the mains and pumping equipment required to furnish the very large domestic consumption could also furnish the fire service without seriously overtaxing their capacity.

The operating expenses incurred in furnishing fire service are usually only a very small part of the total operating expenses, and include such items as the maintenance, repairs and testing of hydrants, in addition to a very small percentage of other operating expenses.

Interest, depreciation and taxes on all of the value of service pipes, meters and meter settings, and on the percentage of the value of the rest of the system not already charged to fire service, should be paid for by the rates for domestic service, which rates would also have to provide almost all of the operating expenses.

Having determined approximately the gross amounts to be derived as revenue from fire service and domestic service, respectively, it would next be in order to divide the fire service revenue into the revenue from public fire service and that from private fire service, and to divide the domestic revenue into flat rate revenue, revenue from water supplied through meters, and service charges on metered connections.

Public Fire Service.—Public fire service, by which is meant the service furnished by the water works system through the hydrants of the city, should naturally be paid for by the taxpayers, as are the costs of operating the police department and the health department.

It has unfortunately been the practice in the past to make the payment for municipal or public fire service take the form of hydrant rentals. This has resulted in causing the municipality which pays these rentals to reduce the number of hydrants to the minimum, and thus greatly impair the fire protection furnished.

Furthermore, the aggregate amount of hydrant rentals paid is invariably too small to pay for proper fire service. This is partly due to a lack of local appreciation of the value of good fire protection, and partly to the fact that the funds from which the hydrant rentals have to be paid are the only funds which the city officials have to spend; and these officials, who are a party to the fixing of water rates, naturally desire to make the inroads on their spending money as small as possible.

A much fairer basis for payment for fire service, and one which would diminish the incentive on the part of the city to reduce the number of hydrants, would be to charge a fixed sum per annum for the fire service furnished by the water works system as it exists today, and to charge a fair rate on the cost of future main extensions, expressed in terms of cents per linear foot of each diameter of main, and thereafter to charge only the fixed charges and maintenance charges on such additional hydrants as the city might desire to have set.

In consideration of its payment for extensions, the city should have the right to order mains laid wherever it might desire; but the size of the mains should preferably be left to the judgment of the company, which would naturally be in a better position to know the proper sizes of pipe to lay, having in mind the future general devolpment of its distribution system as a whole. In order further to diminish the tendency on the part of the city to skimp the number of hydrants, the payment for the main extensions should include proper service charges on a sufficient number of hydrants, to be set where directed by the city, but at an average distance of not more than 400 ft. apart. This spacing along the line of each main would usually be adequate in residence districts. The gridironing of mains in the congested value district will double the number of hydrants in any given area, and thus provide the closer spacing required in that district. Suggested annual charges for main extensions, including the installation of 6-in., two-nozzle hydrants within 15 ft. of the main, and spaced, on the average, 400 ft. apart, would at present prices, be as follows:

6-in. mains, from 12 to 18 ct. per linear ft.
8-in. mains, from 15 to 25 ct. per linear ft.
10-in. mains, from 20 to 30 ct. per linear ft.
12-in. mains, from 25 to 35 ct. per linear ft.
14-in. mains, from 30 to 40 ct. per linear ft.
16-in. mains, from 40 to 50 ct. per linear ft.

The foregoing prices include only that proportion of the expenses connected with these mains which is fairly chargeable to fire service alone, leaving all of the other costs to be borne by the domestic service rates. As these extensions are nearly always made into new territory, the company will usually have to wait some years before the cost of an extension is fully taken care of by the revenue derived from it.

Private Fire Service.—Private fire service should, of course, be paid for by those who are its special beneficiaries.

Such service is usually furnished to large factories, department stores or the like. The owner of the premises supplied with private fire protection receives not only a yearly cash benefit measured by a large reduction in his insurance premiums, but also a further substantial benefit in the form of protection against loss of business or other fire loss not covered by insurance.

The openings on his fire protection system are on his premises, and most of them are on the inside of the building. They are not accessible for use by other parties. Should he happen to be dishonest enough to do so, he could in many cases draw without detection large quantities of water for use for purposes other than fire protection. For these and many other good reasons, a charge for private fire protection is fully justified, and the propriety of such charges is now recognized by all courts and commissions.

It is somewhat difficult to arrive at the proper rates for private fire service, but the general tendency of the most advanced modern practice is to make a fixed charge, based on the size of the connection, to which charge there is added so much per annum for each private fire hydrant, and so much per annum for each sprinkler head supplied through the connection. One thing is reasonably certain, and that is that in no case which has come under the writer's observation, has the charge for fire protection been anything like as large as the special benefit derived by the property owner to whom the service was furnished.

As an illustration of the saving which is sometimes effected, one of the writer's clients was offered by a company engaged in installing sprinkler systems, an agreement which provided that the contractor would install the sprinkler system free of charge other than the saving in insurance rates for four years, and that at the end of the four years the contractor would turn over the sprinkler system to the owner of the property, who thereafter would have to pay only the reduced insurance rates. In the case in point, the contract price of the sprinkler system approximated $17,000, which sum included the contractor's profit. The insurance premium on the plant without the sprinkler system was about $5,000, and with the sprinkler system, about $700. When the owner of such a plant could save, after four years, approximately $4,300 per year in insurance premiums alone, any charge that might be made to him by the water company or water department at anything like the usual rates for sprinkler connections, would be but a small percentage of the benefit derived by the owner in reduction in premium alone. That his risk of fire loss would also be reduced goes without saying, for the reduction in premium speaks for itself.

The following suggested schedule of annual charges for fire service, while admittedly not based on accurate data, is believed to be at least conservatively moderate:

	Per annum.
Minimum charge for connection to private fire hydrants or hose outlets on private standpipe	$60.00
Minimum charge for connection to automatic sprinkler system	60.00
Charge for double nozzle fire hydrants, each	60.00
Charge for single nozzle fire hydrants, each	40.00
Hose connections, other than through fire hydrants, each	25.00
Automatic sprinkler heads, each	.08

With the method of analysis herein propesed, the payments for private fire service are deducted from the gross revenue for the entire fire service; so that in the long run the rates for private fire service go to the taxpayer rather than to the water company or water department.

Sprinklers are admittedly a very efficient means of checking fires, but their action is essentially "first aid" in its character. The first few sprinkler heads that go off will put out a fire if the fire is to be put out at all by sprinklers. If the fire once gets beyond control of the first few heads, all of the remaining sprinklers will serve only to waste water, and the draft which would thus be made on the mains might cripple the efficiency of the water works system at a very critical time. Unless there are some unusual conditions which call for a larger size, a 4-in. connection would supply a sufficient number of heads to check any fire if sprinklers alone will check it at all.

Domestic Service.—The total revenue required from domestic service having been determined, it will next be in order to divide this revenue into the revenues to be derived from fixture rates and from meter rates, respectively; the revenue from meter rates being in turn subdivided into that from service charges to metered consumers, and that from the quantity rates for water furnished through meters.

Fixture rates, because they offer practically no basis for equitable apportionment, and because they encourage leakage and waste, should be eliminated wherever possible, and all services should be metered wherever economically practicable.

The first fixture rates were established by guess, and the existing ones are not, as a rule, much better in that respect. No attempt will be made here to suggest a schedule of fixture rates; but it would be a good plan in fixing such rates to see that they are high enough to offer the consumer a chance to save some money by the installation of a meter.

Service charges for metered connections correspond, in a large measure, to the ready-to-serve charges, or connected-load charges, of the light and power utilities.

They should include at least all of the fixed charges and operating expenses directly chargeable to the service pipe and the meter and meter setting, and under a strict interpretation of the principles of fair rates, they should also include, in each case, the fair proportion of all of the ready-to-serve charges on all the other parts of the plant devoted to domestic service. The inclusion of these latter items would, however, make the service charges too large for practical purposes, so that it is thought advisable to include most of these items in the first and higher quantity rates for meter service. This arrangement not only makes a close approximation to a fair distribution of rates, but also tends to prevent much leakage and waste of water—a result which the old minimum meter rate generally failed to accomplish.

Under ordinary conditions, and at present prices, proper service charges for metered connections, where the cost of the service pipe in the street is borne by the consumer, would run about as follows:

Size of meter.	Per annum.
⅝-in.	$5.40 to 6.60
¾-in.	7.20 to 8.40
1 -in.	8.40 to 9.60
1¼-in.	9.60 to 10.80
1½-in.	12.00 to 13.20
2 -in.	24.00 to 30.00
3 -in.	48.00 to 60.00
4 -in.	72.00 to 84.00
6 -in.	96.00 to 108.00

If the company or water department should install the service pipe, then the foregoing charges should in each case be increased by the annual fixed charges, maintenance and repairs on the service pipe.

Quantity rates for metered water should be paid in addition to the service charges above referred to. The proper adjustment of these rates to any particular city can only be made after a careful analysis of the bills paid by the existing metered consumers.

It is essential, first, that the quantity rates for metered water should not be discriminatory, and that each consumer should pay the same price per gallon for like quantities of water registered by the meter; and, second, that these rates be so adjusted that those items of ready-to-serve cost not already included in the service charges should be absorbed in the quantity rates for the first water used. This is in accordance with the universally recognized commercial practice which distinguishes between wholesale and retail prices.

For simplicity in bookkeping, it is preferable to have not more than three blocks of quantity rates. The amounts of water to be furnished to each consumer in each of the first two blocks can, like the rates themselves, only be fixed after a careful analysis of all of the water bills.

Present Conditions Make Higher Rates Necessary. The effect of the present high prices on fair rates is three-fold. In the first place, the high prices have increased the value of all property—land, houses, food, clothing, and everything else. Public utility properties are no exception to the rule, and the fair value of such property, which is the amount on which the rates should be paid, is today much larger than it was a few years ago. In the second place, operating expenses of every description are now very much higher; and in the third place, the current rates of interest have increased to a point where public utilities which could formerly borrow money at 7 per cent now have great difficulty in obtaining it at 9 per cent.

From this it follows that the water rates which formerly paid somewhere near a fair return should now, in common justice, be very considerably increased.

The people who pay the rates are, in the aggregate, earning more money than ever before, and the value of everything that they own, as well as the price of whatever they buy, has increased. There is no reason why water service, which now costs so much more to supply, and which happens to be about the smallest item of annual cost in the expenses of every householder, should not share in the general increase.

Some companies are so desperately in need of large rate increases at the present time that they cannot meet their current expenses, much less extend their mains or give even reasonably good service.

Out of seven cases in which the writer has been retained in various parts of the country during the past year, one company has received temporary relief, pending the final decision of the utility commission; another received an increase in rates, but its operating expenses have grown so much in the meantime that it has already had to apply for another increase; in three cases no increase has yet been granted; in the other two no hearing has yet been held.

In every one of the above cases the public is suffering from the inability of the company to make extensions and give proper service.

Good water service is cheap at any price, but it can only be supplied when funds are available to pay its fair cost.

No one can tell what future conditions will be; but the existing ones call for immediate relief; and no consideration of past low prices, or of the probability of some reduction in the present prices within the next few months, should deter any rate-regulating body from granting now the increases called for by present conditions; for it can always reduce the rates whenever a reduction in prices makes it proper to do so.

Welded Joints for Steel Pipe of Butte Water Supply Line

The recently completed 28-mile water supply line of Butte, Mont., is composed partly of 26-in. and 24-in. steel-banded redwood stave pipe, and partly of 26-in. and 24-in. ½-in. thick, double-coated steel pipe, the sections being on the average 17½ ft. in length and weighing from 2,000 to 2,400 lb., according to diameter. The wood pipe is used up to a hydrostatic pressure of 300 lb. per square inch, and the steel pipe for pressures in excess of 300 lb. There are approximately five miles of the steel pipe in which the working pressures vary from 350 to 400 lb. per square inch. In one place a grade of 38° is maintained for a distance sufficient to elevate the line 400 ft., and there is a lift of 800 ft. in a distance of 3,000 ft.—from pumping plant to standpipe. The joints of the steel pipe were welded by the oxy-acetylene process by F. E. Woodbridge of Butte, Mont., using Oxweld equipment.

Portion of Welded Pipe Line of Butte, Mont.

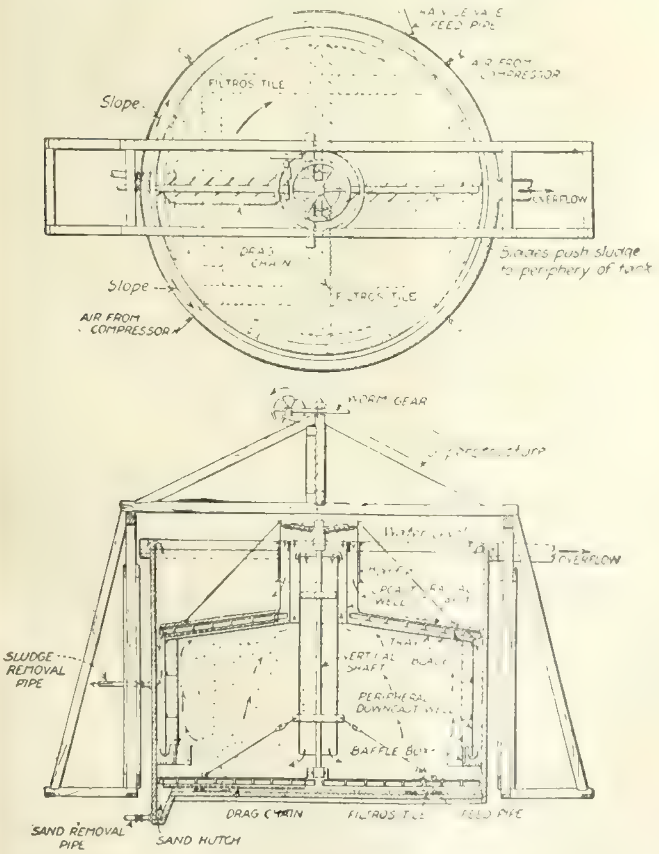
The method of welding the steel pipe was as follows: Joints were lined up by means of pump jacks and held in position by steel clamps made of ¾-in. strap steel 3 in. wide. The joints were then tacked in four places, after which the operator proceeded from any one of the tacks as a starting point. It was possible in many cases to turn jointed lengths 200 ft. long to 300 ft. long at one time, thus enabling the welder to operate continuously on top of the pipe. Where long curves were necessary many of the joints were made by the operator welding around the pipe in place, but supported on skids. The curves were very numerous on this work and the joint construction was so carried out as to distribute the bend over several connections, a small amount being allowed for each weld. In lowering the welded pipe in the trench the pipe was suspended over the ditch by 8x8-in. skids for distances of from 300 to 400 ft. and when ready for the trench, one end was slightly raised with the pump jacks to allow removing the skids at that point, when the unsupported end was allowed to drop into the ditch. The succeeding skids were then taken out in a similar manner and succeeding sections of welded pipe were thus lowered to the bottom of the trench. In some cases there were as many as seven joints suspended between the point of the jack and the first skid.

Experiments with Modified Activated Sludge Process at Mount Vernon, N. Y.

Experiments during the year 1919 at Mount Vernon, N. Y., with a modification of the activated sludge process of sewage treatment by the Dorr Co., Engineers, New York, indicate some unusual and interesting results with this method. The modification has been called the "Dorr-Peck Process" after Mr. C. Lee Peck, director of research and development of the company's sanitary engineering department, who was responsible for the inception and successful development of the experimental work. Mr. R. H. Eagles, of the Sanitary Engineering Department of the Dorr Co., has described this process and given some results of the experiments at Mount Vernon in a paper presented before the Sanitary Section of the Boston Society of Civil Engineers, and the following data is abstracted from this paper.

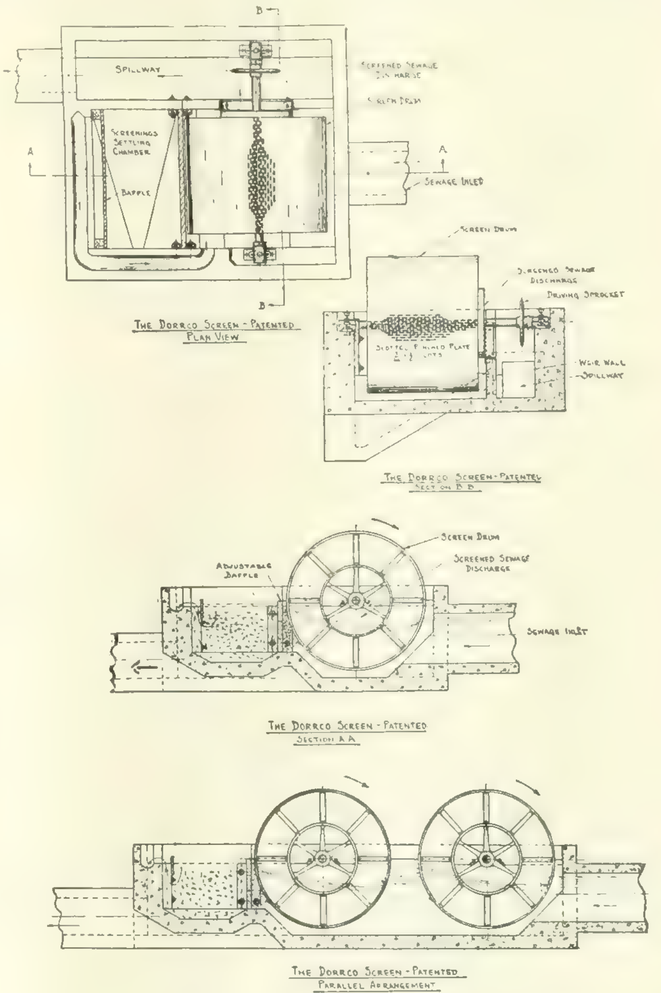
The experimental plant was installed by courtesy of the city authorities and consisted of a fine screen and duplicate aeration units designed to treat a flow of 45,000 gal. per day. The fine screen is of the rotary drum type, known as the Dorrco screen. The screen was a twill weave brass screen-cloth with 20 meshes to the inch and apertures .017 in. square. The average removal of suspended solids over a period of 30 days was 12.2 per cent.

The two aeration units were designed in duplicate as shown in the accompanying figure and operated in series. The sewage is delivered at the top of the central downcast well, and is instantly mixed with 20 times its volume of the freshly activated mixture, which is brought up from the aerating chamber and delivered at the surface from the throat of the airlift formed by the constricted annular well surrounding the central downcast well. The cycle is a rapid elevation of the activated mixture from the aerating chamber to the surface, receiving the small proportion of fresh sewage, and a quick passage down again. There is a continuous displacement from the circuit of a volume equal to the incoming sewage, and this is pushed over into the outside annular well (which acts as a feed baffle and distributor); thence it flows to the quiescent sedimentation chamber in the upper portion of the tank. The liquor is overflowed peripherally from this chamber, the solids settling to the tray bottom, where they are mechanically pushed to the peripheral downcast wells, dropping through to the aeration chamber and entering the circuit again.



Dorr-Peck Activated Sludge Tank.

A small amount of short-circuiting occurs in the displacement of feed to the sedimentation chamber, partly due to the small-size units used. That is, a small portion of the fresh sewage is pushed direct to this chamber without having passed around the circuit for proper aerobic treatment. For this reason a duplicate unit is placed in series, taking its feed from the peripheral overflow of the first unit. Here the cycle is identical except that 75 per cent of the oxidation or activation having been effected in the first unit, a correspondingly reduced amount of air is supplied to the second unit.


B
Spillway
Screened sewage discharge
Screen drum
Screenings settling chamber
Baffle
A
A
Sewage inlet
B
The Dorrco Screen - Patented
Plan View
Screen drum
Screened sewage discharge
Driving sprocket
Slotted finished plate
Weir wall
Spillway
The Dorrco Screen - Patented
Section B B
Screen drum
Screened sewage discharge
Adjustable baffle
Sewage inlet
The Dorrco Screen - Patented
Section A A
The Dorrco Screen - Patented
Parallel Arrangement

Plan and Sections of Dorrco Screen.

In order to secure a supply of biologic sludge in the second unit to complete the purification, no sludge is withdrawn from the first unit; it is allowed to build up in the sedimentation chamber and overflow with the partly purified liquor. The only point of sludge withdrawal is from the tray bottom of the second sedimentation chamber, where it is withdrawn as required to keep it from building up and overflowing with the finally purified effluent.

The average air requirement was 0.6 cu. ft. per gallon of sewage treated, maintained uniformly over a period of two months. The detention period through the system ranged from 8 to 10 hours. A clear, colorless effluent was produced, containing less than 20 p.p.m. of suspended solids, up to 1 p.p.m. of nitrate and nitrate nitrogen, and was stable at least 6 days to the methylene blue reaction at room temperature. A 90 per cent removal of bacteria was effected, and the oxygen-consuming power was reduced 80 per cent. The sludge contained 7 to 9 per cent of nitrogen, on dry basis, expressed as ammonia.

The sewage treated was fresh domestic sewage of the following average composition:

Total solids, 596 parts per million.
Suspended solids, 245 parts per million.
Dissolved solids, 351 parts per million.
Alkalinity, 265 parts per million.
Oxygen consuming power, 154 parts per million.

The average flow treated was 45,000 gal. per day. The two aeration-sedimentation units consisted of cylindrical wood tanks, each 12 ft. in diameter by 11 ft. deep, combined capacity 17,600 gal. Each tank was equipped with a Dorr tray thickener mechanism, the lower arms being equipped with squeegees to move any heavy grit to a peripheral sand hutch, for removal as required. The upper set of arms swept the surface of the tray bottom of the sedimentation compartment, moving the sludge to the peripheral downcast wells for re-circulation, and preventing accumulations of septic masses. In the case of the second unit, the squeezing effect of the plows tended to dewater the sludge to ultimate density for final withdrawal. The thickest sludge removed, however, contained 98.5 per cent. moisture, due chiefly to the small size of the unit which transmitted slight disturbances, interfering with the normal de-watering operation.

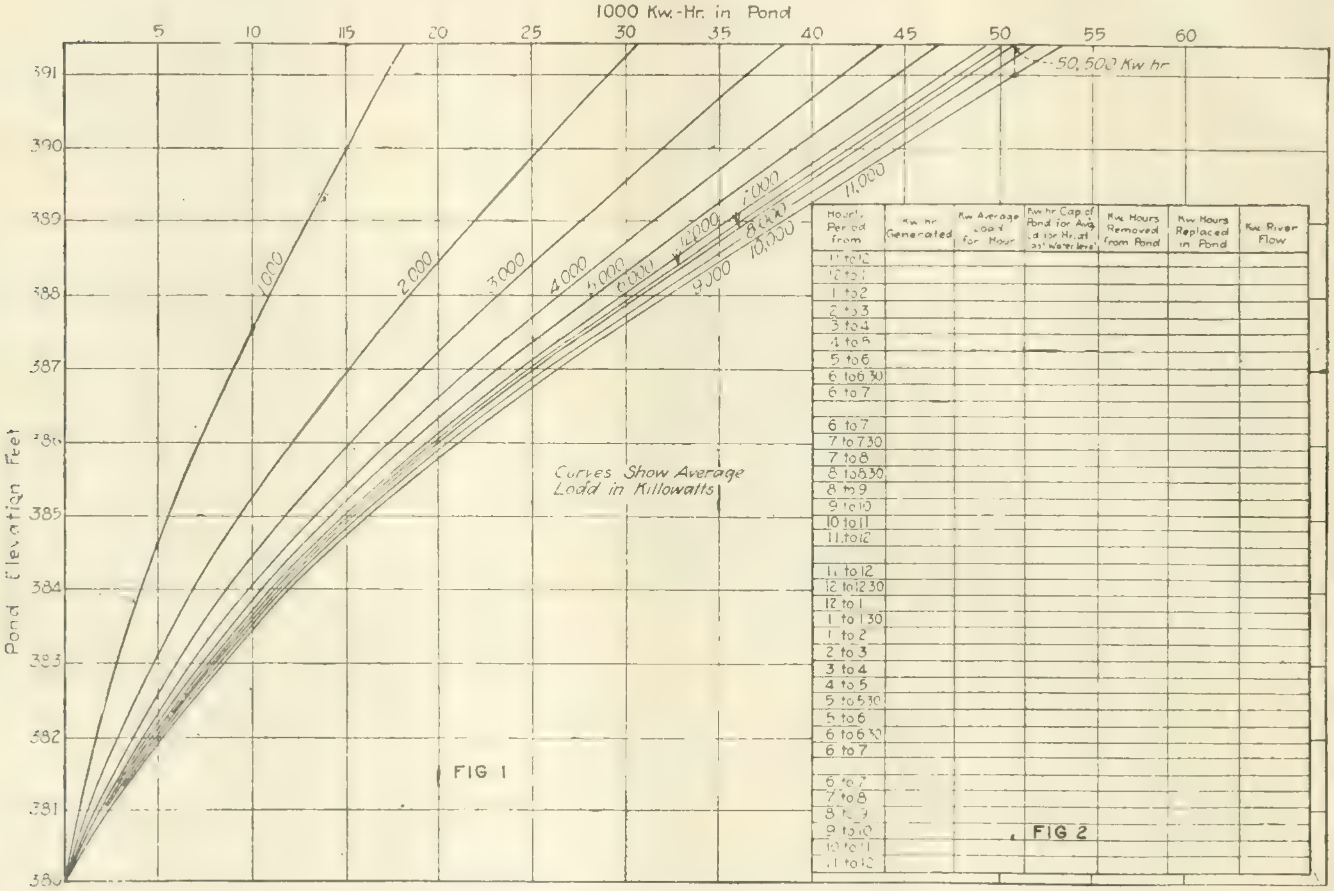
The air was supplied by a Nash hydroturbine compressor, and was measured by the Rotary Meter Co.'s compensating meter, which is so designed as to compensate for any air pressure applied, registering only the actual amount of free air passed. The meter was frequently checked by mercury manometer readings through an orifice, and found accurate. The sewage flow through the plant was recorded over a 90° V-notch weir, by a Foxboro recording depth gage.

Filtros tile (Grade E) was used as a diffusing medium, with satisfactory results. No measurable building-up of pressure through clogging was registered during the five months' period of operation. Furthermore, the air supplied by the Nash compressor is quite free from dust, due to a water-washing action which is a part of its operation.

An experimental Dorr-Peck plant on a 200-gal. daily basis is now in operation at Urbana, Ill., under the direction of the Illinois State Water Survey Division. This experimental work was started under the supervision of Col. Edward Bartow. The Corn Products Refining Co. is also installing a small experimental unit at its Argo plant, to test its efficiency as compared with other methods. This plant will operate chiefly on the factory waste waters. The experimental work will be directed by the staff of the Sanitary District of Chicago.

Measuring River Flow for Hydro-Electric Plant Operation

In the combined operation of steam-driven and hydraulically-driven generating plants very substantial economies can be effected by the proper distribution of the load between them. This is especially true in cases where the river flow is variable. The problem of measuring this river flow in some easy, practical manner, so as to give the load dispatchers a fairly accurate basis to work on, is fundamental. A practical method of measuring this flow, based on storage capacity above the dam, has been devised by R. D. DeWolf, Chief Operating Engineer, Rochester Gas & Electric Corporation, and is described by him in an article in a recent issue of Power, from which the following is taken.



Hourly Period from	Kw hr Generated	Kw Average Load for Hour	Kw hr Cap. of Pond for Avg. Ld for Hr. at ... Water level	Kw Hours Removed from Pond	Kw Hours Replaced in Pond	Kw River Flow
11 to 12						
12 to 1						
1 to 2						
2 to 3						
3 to 4						
4 to 5						
5 to 6						
6 to 6 30						
6 to 7						
6 to 7						
7 to 7 30						
7 to 8						
8 to 8 30						
8 to 9						
9 to 10						
10 to 11						
11 to 12						
11 to 12						
12 to 12 30						
12 to 1						
1 to 1 30						
1 to 2						
2 to 3						
3 to 4						
4 to 5						
5 to 5 30						
5 to 6						
6 to 6 30						
6 to 7						
6 to 7						
7 to 8						
8 to 9						
9 to 10						
10 to 11						
11 to 12						

Figs. 1 and 2.—Charts for Estimating Pond Capacity and River Flow.

A determination was first made of the capacity of the pond in cubic feet so that the volume of water contained in the pond for any elevation was known. Knowing the amount of water contained in the pond, the head on the wheels, and the turbine and generator efficiency for a given load, it is evident that the number of kilowatt hours that can be generated at that load if all the water in the pond were passed through the wheels can be calculated. Assuming that the hydro-electric plant would be supplied only with water from the pond and that no additional water was entering, the curves shown in Fig. 1 were plotted. In these curves, instead of using cubic feet pond capacity, the capacity is expressed in thousands of kilowatt-hours. At an elevation of 391 ft., for instance, the capacity of the pond when the water is used at maximum efficiency is 50,500 kw.-hr. In the case of the two 12,000-kw. generators used for the particular installation for which these curves were calculated, the maximum efficiency is at 10,000 kw. with very little change in efficiency for any load between 9,000 and 11,000 kw. on the unit. If the load on the unit is above or below this amount, the efficiency at which the water is used is decreased; consequently, when a given amount of water is passed through the wheels, a smaller number of kilowatt-hours will be generated, due to the decreased efficiency in the use of the water. Therefore curves for other loads than the 9,000 to 11,000 kw. loads were calculated and plotted on the chart. For example, with a load of 5,000 kw., the kilowatt hours in the pond at the elevation of 391 ft. amount to only 44,500, a loss of 6,000 kw.-hours due to decreased efficiency at which the wheels are operated.

The load dispatchers are provided with a form for entering the necessary data to calculate the river flow as shown in Fig. 2.

To illustrate the use of the method, let us assume the following data:

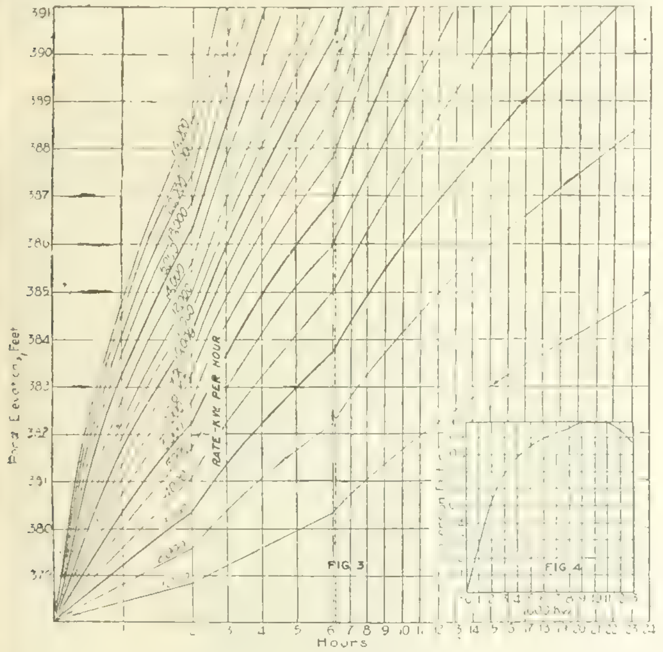
At 9 a. m. the pond elevation is 391 ft. and at 10 a. m. the elevation is 390 ft. and the total generation by two generators for the hour has been 20,000 kilowatt-hours, equivalent to an average load of 10,000 kw. on each generator.

Referring to the chart we get the following information:

	Kw.-hr.
Pond capacity at 9 a. m., at a load of 10,000 kw.	50,500
Pond capacity at 10 a. m., at a load of 10,000 kw.	11,500
Kilowatt-hours removed from the pond during the hour	6,000
Total kw.-hr. generated during the hour	20,000
Less kw.-hr. removed from pond	6,000
Difference equals river flow	14,000

By making this calculation every hour continuous check can be kept on the river flow.

In the left-hand column of Fig. 2, the half-hour periods are put in during the time when the system load is changing rapidly. During this period half-hour readings are taken, but the kilowatt river flow estimated from these readings is not used except as a very rough check on the river conditions. It was found from experience that, with the conditions existing in the pond, half-hour period readings did not seem to be long enough to iron out various inconsistencies and give reliable data. It has therefore been made a practice in estimating the kilowatt river flow to use only hourly periods. The hourly tabulation is arranged in the various vertical groups so as to give space for totalizing each group and figuring average results for each group. The load conditions are such that it has been found convenient to divide the day into four periods—from midnight to 7 a. m.; 7 a. m. to noon; noon to 7 p. m., and 7 p. m. to midnight. For convenience the readings from 11 p. m. to midnight, from 6 a. m. to 7 a. m., from 11 a. m. to noon, and from 6 p. m. to 7 p. m. are repeated. These repetitions are not necessary, but the operators have found it convenient to handle it in this way. In figuring the river flow for each group this overlapping of one hour gives a more reliable average figure. The various vertical groups contain a different number of units, depending upon how many half-hour periods happen to fall in a given group.



Figs. 3 and 4.—Charts for Calculating Period That a Given Load Can Be Carried with Pond at a Given Level.

In constructing the curves shown in Fig. 1, it is not absolutely essential to have a survey of the pond, as these curves can be constructed by a series of approximations from the operating data only. Assuming that only very rough information is available in regard to the pond capacity, a set of curves could be plotted based upon this rough estimate. In the course of operation there will be periods when the amount of power being generated by the plant will be only a relatively small amount greater than the river flow, so that the rate of fall of the pond will be slow, thus minimizing the effect of hydraulic gradient. These operating results will give certain river-flow figures. Taking the average of these figures over a period of, say, three hours, a determination can then be made along the general lines indicated in the following calculation:

Average flow, in kw., for a period of three hours	15,000
Pond capacity, in kw.-hr., from given curves at end of this time	50,000
Kilowatt-hours generated during next period of five hours	100,000
Capacity, in kw.-hr., from given curves, at end of the five hour period	20,000
Kw.-hr. generated by river flow of 15,000 kw. for five hours	75,000
Kw.-hr. actually supplied by pond	25,000
Kw.-hr. apparently supplied by pond as shown by curve	30,000
Error in pond capacity in kw.-hr.	5,000

By choosing a period during which it is fairly certain that the river flow is constant over the assumed period of five hours, as given, this method can be used to determine the inaccuracy in the assumed chart, and after such determination a corrected chart can be made. This corrected chart can be again checked in the same way and a third chart made which will be more nearly correct than the second.

The results secured by the foregoing method can be checked by still another scheme. During periods of operation when the pond is drawn down low during the heavy-load period of the day and allowed to fill up during the light-load period, if we start at a time when the pond is full and take hourly readings during the period when the pond is being emptied and filled, it is evident that at the end of the filling period the river flow will have been sufficient to generate the total kilowatt-hours generated from the start. The average river flow will then be the total kilowatt-hours generated, divided by the total time. For any hour a comparison can be made between the kilowatt-hours removed from the pond as determined by subtracting the average river flow from the total killowatt-hours actually generated for that hour, and the kilowatt-hours removed from the pond as determined from the chart by the method outlined in the foregoing.

Even in cases where an accurate survey of the pond is available, the methods outlined can be used to check the pond from time to time to determine the amount that it has silted up.

In order to assist the load dispatcher in estimating the number of hours that he will be able to carry a given load with a pond at any given level, the chart shown in Fig. 3 was drawn up. The curves on this chart represent the rate at which the pondage is being depleted. For example, if the pond elevation was 387 ft. and the load carried by the station such that 6,000 kw-hr. were being taken out of the pond every hour, these curves show that this load could be carried for about six hours, at the end of which time the pondage would be all used up. These curves are based upon an assumed operation of the wheels at their highest point of efficiency. In case the wheels are not operated at this point but at a less economical load, use is made of the conversion factors shown in Fig. 4. In the case cited, for instance, if the load being carried by each machine was only 7,000-kw., then the length of time that the pondage would last would be only 93 per cent of six hours, or 5 hours and 34 minutes.

This system has been in use for a number of months, and on the whole the results have been found very satisfactory. Irregularties in the pond capacity have been found and corrections made from time to time to overcome these errors. A great deal has been learned about hydraulic gradient and its effect on the load conditions, and from experience the dispatcher makes allowance for the effect of this factor.

Unusual Feature of Iowa Engineering Society's Meeting.—The Engineers' Club and the Chamber of Commerce of Des Moines, Ia., are making special provisions for the entertainment of the wives of visiting engineers at the Iowa Engineering Society's annual meeting. Engineers have been urged to bring their wives to this meeting. Among other things, the ladies' section of the program includes an afternoon tea at the Hoyt Sherman Place, a theater party, banquet and dance. The society meets this year at the Chamberlain Hotel in Des Moines, Ia., Jan. 18-19 and 20.

Adoption of Sound Engineering Principles in Use of Fuel Would Save 75,000,000 Tons of Coal Per Year*

By DAVID MOFFAT MYERS.

Seventy-five to one hundred million tons of coal per year could be saved by the adoption in the United States of well-known and well-tried methods of fuel conservation, and this saving would be in addition to a similar reduction in the consumption of other fuels. The writer's experience in the Fuel Engineering Section of the United States Fuel Administration demonstrated without possible doubt that such conservation would involve no experimental features, and that it could be readily accomplished by the simple adoption of sound engineering principles in the use of fuel by consumers. Prevention of waste is merely a matter of the application of well-known engineering principles.

Based upon only 75,000,000 tons, the money saving would be $450,000,000 per year, or enough to pay nearly one-half the interest of our national war debt.

The transportation of coal would be relieved to an extent equivalent to a million and a half 50-ton carloads per year, or 50 per cent more than the coal-carrying capacity of the Pennsylvania Railroad lines east of Pittsburgh. The significance of this will be realized when it is stated that the chief difficulty in securing coal today is due to lack of transportation facilities.

The services of 75,000 miners would be conserved, so that the same force would be able to handle the natural increase in mining production. The additional labor connected with the loading, transportation, and unloading and firing of a million and a half less cars of coal per year would also be eliminated.

Fuel conservation is good for other countries, as it enables us to do our part in supplying their markets. It should be emphasized at this point that the kind of conservation which the writer has in mind is "constructive conservation," which means using fuel efficiently without reduction in the output of our manufactured products and without the slowing down of any of the natural phases of our national and social life. It is necessary to inject this statement owing to the fact that during the war "destructive conservation" was also largely practiced, which simply means the cutting off of coal supply to various industries and uses with the consequent impoverishment of our industrial and social life.

All consumers of coal would benefit financially by a program of constructive conservation. During the war, by the adoption of very simple rules governing methods of operation alone in our power plants and on our railroads, an annual saving of 25,000,000 tons of coal per year was effected with the program in operation in 25 states for an average time of less than four months. It was impossible, at that time, owing to conditions imposed by the war, to adopt measures affecting also the design or equipment connected with the use of fuel. A future program should include such measures. The efficiency of any process that is connected with fuel or any other material is equal to the efficiency of the operation multiplied by the efficiency of the equipment. In other words, the man multiplied by the machine.

The Waste of Fuel in the United States.—There is at present a huge and unnecessary waste of fuel in this country. The waste is everywhere. There is not an industrial plant in the country where 10 to 30 per cent saving of fuel might not be effected by common-sense engineering. Some of the items relating to this waste are as follows:

(1) Waste in the boiler plant, including the very large item of inefficient combustion of fuel under stationary and locomotive boilers. Sixty-seven per cent of all the coal mined in this country is consumed for the purpose of making steam [illegible]

(2) Coal consumed in the old-fashioned, wasteful beehive coke ovens represents 9.3 per cent of the total. Only 4.3 per cent is consumed in the by-product coke ovens.

(3) In domestic heating it is estimated that 12 per cent of the coal is used. Very large savings were made in this department during the war, and much more can be done by proper conservation methods. The psychological importance of emphasizing fuel economy in this field is evident owing to the fact that it would deal with 20,000,000 people or householders, whereas by comparison fuel conservation in the industries would deal with only 200,000 plant managements and those of the railroads.

(4) Fuel is extravagantly wasted by improper use of steam after its generation. For instance, by the use of:

(a) Inefficient types of prime movers.

(b) Careless maintenance of power-consuming machinery.

(c) Ill-advised installations unsuited to the purpose they would fulfil.

(d) Huge volumes of wasted exhaust steam expelled to the atmosphere or to condensers and live steam used for heating without first developing its quota of energy.

(e) Unnecessary use of live steam where exhaust steam with proper engineering would fully meet the requirements.

(f) Badly designed and ill-kept transmission systems.

Of these forms of waste item (d) needs the greatest emphasis. Everyone knows steam is being wasted when they see clouds of exhaust blowing out into the air, but how many people (not engineers) realize that our modern and highly efficient central stations are guilty of wasting some 80 per cent of the heat of the steam into the condenser, while at the same time, particularly during the heating season, hundreds of buildings and factories in the vicinity are burning thousands upon thousands of tons of coal for heating purposes, and that the owners of these would gladly dispense with their expensive heating plants if the central station would sell them heat as well as power.

Fuel Savings in Industrial and Private Plants.—The other side of the problem relates to the private plants, each of which must be diagnosed according to the merits of the case. Many industrial plants can utilize all of the exhaust steam from their own power plants all the year round, and in such cases their power is merely a by-product of their heating fuel. If they were to shut down their engines or turbines they would still have to burn about 90 per cent of their former coal consumption, so that only 10 per cent of their engine water rate is chargeable to power. Such a plant of course produces its own power so cheaply that no central-station condensing power plant will ever be able to compete with it. Frequently it would easily be able to generate more power than it can use without wasting any exhaust steam, under which circumstances it should be enabled to sell its surplus power to a central-station system.

The other extreme exists when the private plant has no use for heat and wastes all of its exhaust to the atmosphere. Coal, and money, too, in many instances, would be saved if the owner shut down his engines and purchased power from a more efficient central plant. There are many stages between these two extremes. For instance, the private plant just mentioned, if the power requirements were sufficiently large could afford to install modern equipment and make its own power more cheaply than it could buy it. Coal might not be saved over the plan of buying power from the central station, but money would. A very common case is that of the private plant that can utilize all of its exhaust heat during the heating months but wastes it through the non-heating months. Such a plant should make its own power in cold weather and buy it in warm weather. What we need to develop is a flexible plan of co-operation between the central power stations and the privately owned plants.

The superpower system advocated by W. S. Murray, apparently fails to consider the vital factor of industrial and building heating, and unless this factor is interwoven in the system in the manner the writer has indicated above, the waste of steam and fuel (to the condenser) in large central stations would be augmented rather than reduced. If power alone were the only consideration necessary, Mr. Murray's plan would avoid this important fault. As applied to the railroads alone, which consume 28 per cent of all the coal we produce, the plan would appear to have many important advantages.

Our Failing Supply of Fuel.—The need of a definite policy of fuel conservation is urgent. Natural gas, the most nearly ideal of all our natural fuels, today is practically gone. Inside of three years there will be no more available for industrial uses, and all owing to our failure to demand a definite policy of conservation. We permitted instead a definite policy of waste.

The next natural fuel to go will be oil. The supply in the

[illegible]

United States it is estimated will be used and wasted out of existence in 20 to 30 years. Our production is stated at 1,000,000 bbl. of crude oil a day, which is more than 60 per cent of the world's total output, but this is not enough for our present domestic consumption. The peak of production will be reached in a very few years, whereas the consumption is increasing steadily. The demand for motor fuels is the greatest of all the items of consumption, and fuel oils is said to be the next largest. A bill has been introduced for an appropriation of $250,000 to enable the Department of Agriculture to conduct experiments looking toward the discovery of a new motor fuel. Coal-tar products including benzol are under consideration as well as alcohol. That the expensive method of producing oil from the shale beds of Utah, Colorado, Wyoming, and Nevada is being more and more brought to the attention of investors, is an indication of the urgency of the oil situation. All this is occurring years earlier than should have been, owing once more to our lack of a definite policy of fuel conservation.

Government Aid in Conservation.—It is now the time to consider how the Government can assist in the conservation of coal and oil. It is the writer's personal opinion that coal and other natural fuels present a problem that so intimately concerns the welfare of all the people that it must equally concern the Government which represents the people, and that therefore until the general public through the Government takes action in the matter there can never be any truly adequate answer to this problem. The mere financial incentive to stop the unnecessary waste of fuel is not strong enough to do the job, for the reason that the great bulk of coal and other fuels is consumed in industrial undertakings, wherein substantial profits are readily available without the trouble of economizing in the application of fuel. This fact may be strikingly realized through the statement of an authority that of the total cost of all the manufactured products of the country only 2 per cent is fuel cost.

The public at large does not yet fully realize the importance of fuel as a national issue, but the writer believes that even now it is coming slowly into such a realization. Therefore, although the time is not yet ripe for any radical step in this direction, yet we may and must look forward ultimately to a solution along these lines.

The public must be made to see how adversely it is affected by this great and uncontrolled waste of fuel so that Government co-operation and assistance will be demanded. This means that time will be necessary in which to educate the public as to the importance of fuel conservation as a national issue in order to secure the necessary interest by Congress and Government bureaus.

A Policy of Fuel Conservation.—Finally, the writer wishes to offer for consideration and constructive criticism the following policy of fuel conservation to be adopted with the co-operation of the Government:

(1) Regulation of quality of fuel.

(2) Measures for prevention of flagrant waste of all fuels.

(3) In the matter of transportation, zoning is productive of large economies.

(4) Better means of coal storage are urgently needed to flatten out load curves at the mines, which are now overcapitalized and overequipped 40 per cent.

(5) Possibilities of conservation by the United States Bureau of Mines.

(6) Great advantages to be secured by appointment of a resident engineer in each state, to keep in close touch with local industries and with a clearing house of information in Washington.

(7) A body of citizens advisory to Bureau of Mines should assist in the planning and development of the conservation program. It should be representative of business men, engineers, and citizens from various parts of the country.

(8) Correct design of new power plants, and perhaps changing of power equipment in existing power plants.

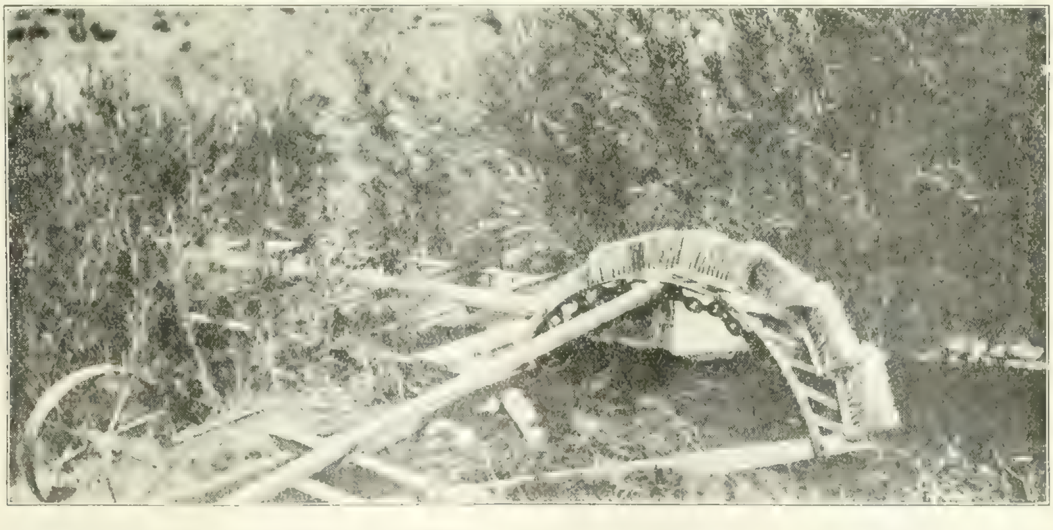
(9) Government should encourage new inventions and investigation, leading to the economical use of fuel.

(10) Better educational measures. Every technical school should have lecture courses on fuel conservation, more for the purpose of emphasizing its importance rather than from intensified and specific instruction. Educational courses for chief engineers and firemen. Examination for license in this profession. Provide throughout the country uniform examinations with corresponding certificates for operating engineers and firemen thus educated in steam and fuel economics.

(11) Measures looking toward the development of low-temperature distillation of coal (and lignite) for the conservation of the immensely valuable by-products which at present are wasted when raw coal is burned for steam making. The resulting smokeless carbonized coal would then become the boiler fuel of the future in proportion to the extent to which this by-product industry could be economically developed.

Scrubber for Cleaning Irrigation Flumes

A number of heavily-bristled scrub brushes attached in a semi-circle to the base end of a triangular frame which is supported at the apex by a small wheel, has proved an excellent device for scrubbing off moss and silt from the interior of semi-circular flumes, according to the December Highway Magazine.



Device Used in Selah-Moxee Irrigation District for Scrubbing Off Moss and Silt from Semi-Circular Flumes.

The device which was designed and perfected by Charles B. Schmidt, manager of the Selah-Moxee Irrigation District, in the Yakima Valley, Washington, is shown in the accompanying illustration.

The device is shown upside down at the side of one of the flumes which has been cleaned by it. The scrubber is placed in the flume at the head end, with the brushes resting against the sides of the conduit, and the small wheel, which is at the front end of the frame, on the floor of the flume. The flow of water forces the scrubber along, while the wheel guides it, and keeps it from wedging.

As may be noted by close inspection of the device, a heavy iron chain has been attached to add weight and hold the brushes against the sides of the flume.

If conditions warrant, the cleaning operation is repeated a number of times. Where the velocity of flow in the flume is not sufficient to prevent the growth of moss, this means of cleaning the conduit has been found very effective.

Valuations of Iowa City Water Co. Based on Present and Pre-War Costs

Four valuations within the last five years have been made of the Iowa City (Iowa) Water Co., three of them based on pre-war and one on present costs. The valuation based on present prices indicates an average increase of 135 per cent over the pre-war valuations. J. H. Dunlap, Professor of Hydraulics and Sanitary Engineering, State University of Iowa, made two of these valuations, and has prepared a paper which was presented before the Iowa Section of the American Water Works Association recently. The following is an abstract of his paper:

The Iowa City Water Co. is a privately owned company. The population of Iowa City is about 12,000, exclusive of 4,000 students in attendance at the University of Iowa. The plant was originally installed in 1882. The principal source of supply is from infiltration galleries estimated at about ½-mile in length beneath the bed of the Iowa River. Ten 8-in. flowing wells 160 ft. deep contribute a small amount of the water used. At times when these two sources prove inadequate, some water is taken directly from the Iowa River, which is only about 100 ft. from the plant.

The pumping equipment consists of a Holly quadruplex compound condensing crank and fly-wheel steam pump with a capacity of 1,500,000 gal. installed in 1882; a Snow duplex direct-acting compound condensing steam pump with a capacity of 2,000,000 gal. installed in 1889; and an Allis-Chalmers' horizontal cross-compound crank and fly-wheel Corliss type high-duty steam pump with a capacity of 3,000,000 gal. installed in 1914.

In 1909 an iron removal plant was installed by the New York Continental Jewell Filtration Co. There are two sedimentation basins and four rectangular concrete gravity filter units with a capacity of 2,000,000 gal. per day. This plant, which was originally designed as an iron-removal plant, is now serving also as a filtration plant with coagulation with alum and lime supplemented by sterilization by liquid chlorine.

The distribution system consists of 26.4 miles of main-2-in. to 20-in. in diameter.

Since 1915 four valuations of the Iowa City Water Co. have been made. Table I, "Results of Four Valuations of the Physical Property in Use," gives some interesting comparative reproduction values as of April 1, 1920.

In 1915 the company made application to the city council of Iowa City for increased water rates. The city council engaged the writer to report upon the value of the property and the rates to which this value entitled the company. Due to the shortness of the time available for the preparation of the report, it was impossible to prepare a complete inventory of the company's property. The company submitted a statement from its books, which indicated that the value of its physical property new was $245,050. After some investigation it was concluded that this value was a fair one for use in rate-making, but the company was advised to have a complete inventory of its property made as soon as possible. Based upon the company's own estimate of the value of its property, a rate was recommended which was calculated to yield a 7 per cent net return. This rate was accepted by the company with the agreement that it would be tried out to see if the estimated return was received. The new rate was somewhat uncertain in the amount of return since the company was about to change most of its consumers from the flat rate basis to the meter basis. It is interesting to note that the new rate brought in the esimated revenue and provided a small surplus for the year 1916 of $2,675. Part of this surplus, however, was probably due to an energetic campaign for the collection of accounts unpaid in 1915.

TABLE II—PRE-WAR AND PRESENT COSTS USED IN THE VALUATIONS.

Item.	Pre-war costs.	Costs Apr. 1, 1920	Per cent increase.
Cast iron pipe, 6-in. and over, including freight and haul	$ 28.00	$ 77.00	175
6-in. valves	15.50	26.35	70
12-in. valves	41.50	79.50	92
4-in hydrant with two 2½ in nozzles	26.00	58.50	125
6-in. hydrants with steamer nozzles and two 2½-in nozzles	40.00	90.00	125
⅝-in meters installed	9.00	12.50	39
Lumber in place	40.00	100.00	150
Common red brick in place	18.00	53.25	196
Concrete footings	8.00	13.25	66
Excavation	0.50	1.00	100
Cross-compound pumps per M G capacity	3,800.00	10,000.00	163
Boilers, 72 in. x 18 ft., installed	1,400.00	3,800.00	172
Filters per M. G. capacity, with all structures	12,000.00	28,600.00	138

In accordance with the recommendation that a complete inventory and valuation be made, H. M. Byllesby & Co., Chicago, were engaged for the work. Under date of Aug. 1, 1916, a report was rendered which gave $332,082 as the value of the total physical property new. Due to the fact that the president of the Iowa City Water Co. was soon called to service with his regiment on the Mexican border, and later in the war with Germany, no application was made by the company for an increased rate until 1920. In operating during 1917, 1918, and 1919 under this rate, the company lost about $22,000 over what a 7 per cent rate of return would have given.

In order to prevent further losses, the company engaged the writer to make a valuation of its property and to suggest water rates which would yield a fair return. The report made to the company Dec. 31, 1919, showed that on the basis of pre-war costs, the reproduction value of the physical property new was $296,002. The total depreciation of $43,261 was computed by the compound interest method with interest at 4 per cent. The depreciation obtained in this way was checked by a study of the actual condition of the property in use, and wherever necessary was changed to conform with the actual depreciation found on inspection. Subtracting the total depreciation from the pre-war reproduction cost, new, the pre-war reproduction value is found to be $252,741. This is reasonably close to the comparative reproduction value of $241,050 shown in Table I, based on the company's books, and also the comparative reproduction value of $279,514 found by H. M. Byllesby & Co.

The water rates in use since 1915 were as follows:

Fire hydrants	$ 45 per annum
Flush tanks	100 per annum
Water for municipal purposes	Free
Meter rates, payable monthly:	
Service charge—	
⅝-in. meter	$ 0.50 per month
¾-in. meter	0.80 per month
1 -in meter	1.10 per month
1¼-in. meter	1.50 per month
1½-in. meter	2.00 per month
2 -in. meter	3.00 per month
3 -in. meter	5.00 per month
4 -in. meter	10.00 per month
Output charge—	
Up to and including 5,000 cu. ft.	10 ct. per 100 cu. ft.
For the next 45,000 cu. ft.	9 ct. per 100 cu. ft.
For quantities in excess of 50,000 cu. ft.	6 ct. per 100 cu. ft.

As a result of this careful presentation of all the facts involved, the council of Iowa City voted unanimously to allow the company the following increased rates:

All rates to remain the same, except the output charge, which was changed to the following:

Up to and including 5,000 second feet	20 ct. per 100 cu. ft.
For the next 45,000 cu. ft.	15 ct. per 100 cu. ft.
For quantities in excess of 50,000 cu. ft.	10 ct. per 100 cu. ft.

Due to the fact that the company wished to issue additional stock, the writer was requested to report upon the value of its physical property, based on present costs. Based on costs as of April 1, 1920, the reproduction cost, new, of the physical property of the company was $669,833. Subtracting the total depreciation, $91,695, gives a present reproduction

TABLE I—RESULTS OF FOUR VALUATIONS OF THE PHYSICAL PROPERTY IN USE OF IOWA CITY WATER CO.

Item.	Company's [illegible] Jan. [illegible] 1915.	Report by H. M Byllesby & Co., Aug. 1, 1916.	Report by J. H. Dunlap, Dec. 31, 1919. (Prewar costs.)	Report by J. H. Dunlap April 1, 1920. (Present costs.)
[illegible]	[illegible]	$332,082	$296,002	$669,833
[illegible]	[illegible]	59,299	43,261	91,695
Reproduction value of physical structures	[illegible]	$272,783	$252,741	$578,138
New construction less depreciation to April 1, 1920	18,890	7,731	....	....
[illegible]	$241,050	$279,514	$252,741	$578,138

value of $578,138. This is a value of 129 per cent greater than that obtained by using pre-war costs.

In Table II the pre-war and present costs used in the valuations are compared. It will be observed that the per cent of increase of the present costs over pre-war costs varies from 196 per cent for common red brick in place, to 39 per cent for ⅝-in. meters installed.

The great difference between the present reproduction value of the physical property of the company based on pre-war costs and on the costs as of April 1, 1920, is an illustration of the difficulties of valuation work, using the reproduction new less depreciation method, in such general favor with the courts. It is believed that for rate-making purposes some quite different method of valuation will have to be worked out and standardized.

Self Contained Electric Outfit for Thawing Services

A self-contained generating unit, consisting of gasoline motor and specially designed generator, is employed by the Montreal Water & Power Co., Montreal, Que., for thawing out water services. Current for this purpose was formerly obtained from the local power company by means of transformers connected to the 2,200-volt mains and delivering about 400 amperes at about 50 volts. The new outfit, illustrated above, however, has proved successful and much more convenient and rapid in actual service than the former outfits, as well as considerably less expensive.

Gasoline-Driven Thawing Outfit.

Important Papers to Be Presented at Good Roads Convention.—Some of the papers that are to be presented at the 18th annual convention of the American Road Builders' Association, which is to be held Feb. 9 to 12 at the Coliseum, Chicago, are: "Our National Road Problems," by Thomas H. MacDonald, Chief U. S. Bureau of Public Roads; "Sub-Grades," by H. G. Shirley, Secretary Federal Highways Council; "Importance of Drainage in Road Construction," by Prof. F. H. Eno of Ohio State University; "Types of Pavements," by James H. MacDonald, former State Highway Commissioner of Connecticut; "Highway Researches and What the Results Indicate," by A. T. Goldbeck, Chief Division of Tests, U. S. Bureau of Public Roads; "Recent Developments in Road Building," by Edward N. Hines, W. D. Uhler and R. Keith Compton; "Highway Finance," by H. C. Sylvester, Vice President National City Co., and "Relations Between Engineers and Contractors," by D. A. Garber.

U. S. Civil Service Examinations.—The U. S. Civil Service Commission, Washington, D. C., has announced the following examinations: Mining and metallurgical engineer, in Bureau of Mines; $4,000-$5,000; applications must be in by Feb. 15. Hydrographic and topographic draftsman, in Coast and Geodetic Survey; $1,600 to $2,000. Junior drainage engineer in Bureau of Public Roads; $1,500 to $1,920; examination Feb. 9. Associate engineer, $2,000 to $2,800 and assistant engineer, $1,400 to $1,800, in Bureau of Standards.

Fees and Services of Practicing Engineers

Some months ago the national executive committee of the American Association of Engineers appointed a committee of practicing and consulting engineers to consider the scope and practice of engineering activities, the desirability of having uniform practice with reference to fees and scope of services, and the feasibility of establishing such practice. The chairman of the committee is Webster L. Benham, Kansas City, Mo., and the other members are: Louis E. Ayres, Ann Arbor, Mich.; John W. Cunningham, Portland, Ore.; George W. Fuller, New York City; Farley Gansett, Harrisburg, Pa.; Samuel A. Greeley, Chicago; A. N. Johnson, College Park, Md.; Ira W. McConnell, New York City; Langdon Pearse, Chicago; Edgar A. Rossiter, Chicago; Charles V. Seastone, Madison, Wis., and Wilbur J. Watson, Cleveland.

The views of the chairman and a majority of the committee are set forth by Mr. Benham in an article in the January issue of the Professional Engineer, the official publication of the association. This article may be considered to be in the nature of a progress report. The committee will be glad to receive comments from all engineers interested in the subject. The matter following is taken from Mr. Benham's article in The Professional Engineer:

The consensus of opinon of members of the committee seems to be that it is not possible to establish any hard and fast uniform or standard schedule of fees for practicing and consulting engineers for all classes of work and for all contingencies, but it is believed that some definite schedule can be adopted as a basis for minimum charges.

While it is realized that the fee to be charged can not and should not be definitely fixed—because there are numerous and complex factors which enter into the matter, the class of work, difficulty and magnitude of project, the ability, knowledge and training of the engineer, the responsibility assumed by the engineer and the ability of the client to pay—nevertheless we should have some definite basis upon which to base our charges. It appears, therefore, that the best we will be able to recommend is a basis of minimum charges with an increase in amount running into the larger fees for the more experienced and specialized of our engineers. It seems to be the desire of the majority of the committee to draw a line of demarcation between the practicing and consulting engineers and to allow the latter sufficient latitude so as to enable them to obtain higher fees. We must provide, therefore, a definition for these two groups of engineers which we must admit exist.

A practicing engineer may be termed one who is actively engaged in the practice of engineering, such as the making of surveys, designs, plans, specifications, valuations, appraisals and reports and supervising work of construction, and who contracts with his clients for engineering services, as differentiated from the engineer who is employed on a salary basis.

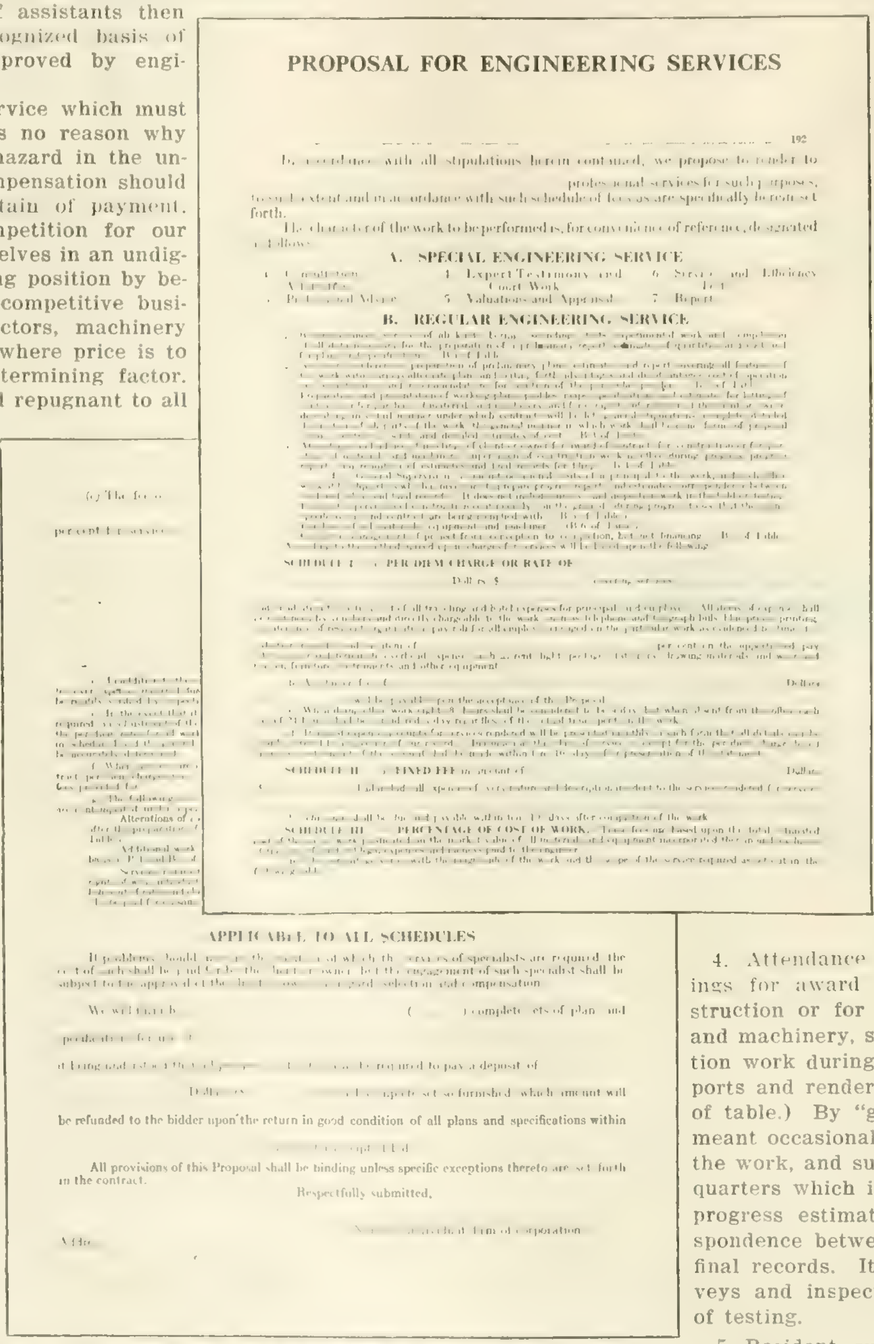
A consulting engineer may be termed one who had highly specialized training and experience in certain lines of engineering and who has mature judgment and experience in general engineering—experience which qualifies him to act in the capacity of adviser to other engineers or directly to their clients, to design and supervise the construction of the more important engineering problems—as apart from the practicing engineer who is engaged in the design and supervision of the more simple projects.

It is generally agreed that there is an urgent need of stopping all "consultants" from charging nothing for their services or ridiculously small fees and doing a correspondingly small amount of work. It is obviously far more economical for the client to pay more for advice and thus enable the engineer to give his work the proper amount of study and supervision. This point can not be too strongly emphasized. It should be an engineering axiom, a principle that the public and the engineers will universally accept. The practice of competitive bidding should be discouraged. One would look with ridicule upon a similar method of employing lawyers and physicians. Except in cases where it is absolutely necessary by reason of adverse laws effecting municipal, county and state work, no work should be contracted for on a contingent basis. In cases of this kind the laws should be amended to enable engineers to be properly compensated. It is neither right nor reasonable to ask an engineer to render free service and to gamble with his client. He should be paid for all he does and a sufficient amount to allow him a fair profit over and above all expenses of every nature.

The practicing and consulting engineer should be able to establish the highest possible standard of salaries for his employes, but he has never been able to pay these proper salaries on account of the low compensation he has been accustomed to receive. The public, on the other hand, has not been educated to appreciate what constitutes a proper fee. If the practicing and consulting engineers are to meet the just advances in their expenses and in salaries of members of their staffs and of assistants then there must be a recognized basis of minimum charges approved by engineers as a body.

Engineering is a service which must be paid for. There is no reason why there should be any hazard in the undertaking and the compensation should be both fair and certain of payment. By entering into competition for our services we place ourselves in an undignified and embarrassing position by being put on the same competitive business basis as contractors, machinery and material dealers, where price is to a large extent the determining factor. This practice is indeed repugnant to all of us, but in many cases we have been forced to countenance it by our submission to the customs which we have carelessly allowed to exist.

From a professional standpoint engineers should stand as high as men of other professions. Their training and skill is at least equal and their responsibilities, it is believed, are even greater than in other professional branches. Then why do engineers not hold the respect of the public? The reason may be that they have had no militant organization to zealously guard their interests and they have not individually done their parts. It is believed, therefore, that a schedule of fees adopted by the American Association of Engineers and given a wide publication will be beneficial to both the practicing and consulting engineers. It is agreed no schedules can provide for all conditions and contingencies which may arise in the practice of the engineer—civil, electrical, mechanical, mining, chemical, metallurgical, geological and others—but we can establish a somewhat definite schedule which it is believed can be elastically applied to all classes of engineering work.



PROPOSAL FOR ENGINEERING SERVICES

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In accordance with all stipulations herein contained, we propose to render to professional services for such purposes, to such extent and in accordance with such schedule of fees as are specifically herein set forth.

The character of the work to be performed is, for convenience of reference, designated as follows:

A. SPECIAL ENGINEERING SERVICE

1. Consultation
2. Arbitration
3. Professional Advice
4. Expert Testimony and Court Work
5. Valuations and Appraisal
6. Service and Efficiency Test
7. Report

B. REGULAR ENGINEERING SERVICE

SCHEDULE I — PER DIEM CHARGE OR RATE OF

Dollars $

SCHEDULE II — FIXED FEE in amount of Dollars

SCHEDULE III — PERCENTAGE OF COST OF WORK.

APPLICABLE TO ALL SCHEDULES

be refunded to the bidder upon the return in good condition of all plans and specifications within

All provisions of this Proposal shall be binding unless specific exceptions thereto are set forth in the contract.

Respectfully submitted,

Name of individual, firm or corporation

Address

Page 1 (Above) and Page 3 of Form of Proposal for Professional Services. Page 2 Contains the Schedule of Fees Printed in the Table.

Suggested Classification of Engineering Services.—As a general guide for the establishment of fees for professional services of engineers, for work in the United States within the field of the engineer, the following is suggested. These can be divided into two classes, as follows:

A. Special Engineering Service—
1. Consultation.
2. Arbitration.
3. Professional advice.
4. Expert testimony and court work.
5. Valuations and appraisals.
6. Service and efficiency tests.
7. Reports.

B. Regular Engineering Service—

1. Reconnaissances, surveys of all kinds, borings, soundings, tests, experimental work and compilation of all data necessary for preparation of preliminary report, estimates of cost and for plans and specifications. (B-1 of table.)

2. Necessary conferences, preparation of preliminary plans, estimates and report covering all features of the work with various alternate plans setting forth advantages and disadvantages, cost of operation and maintenance and recommendations for solution of the particular problem. (B-2 of table.)

3. Preparation and presentation of working plans, profiles, specifications and estimates for letting of contracts or purchase of material and machinery and for complete information of client or owner, describing in detail manner under which contract or contracts will be let, general stipulations, complete detailed description of all parts of the work, general manner in which work shall be done, forms of proposal blanks, contracts and bonds, and detailed estimates of cost. (B-3 of table.)

4. Attendance and advice at meetings for award of contracts of construction or for purchase of materials and machinery, supervision of construction work during progress, progress reports and rendering of estimates. (B-4 of table.) By "general supervision" is meant occasional visits of a principal to the work, and such office work at headquarters which is necessary to prepare progress estimates and reports, correspondence between field and office and final records. It does not include surveys and inspection work in the field of testing.

5. Resident supervision of construction continuously "on the ground" during the progress to see that the plans and specifications and contract are being complied with. (B-5 of table.)

4. Attendance and advice at meetings for award of contracts of construction or for purchase of materials and machinery, supervision of construction work during progress, progress reports and rendering of estimates. (B-4 of table.) By "general supervision" is meant occasional visits of a principal to the work, and such office work at headquarters which is necessary to prepare progress estimates and reports, correspondence between field and office and final records. It does not include surveys and inspection work in the field of testing.

5. Resident supervision of construction continuously "on the ground" during the progress to see that the plans and

specifications and contract are being complied with. (B-5 of table.)

6. Purchase of all materials, equipment and machinery. (B-6 of table.)

7. Complete management of project from conception to completion, but not financing. (B-7 of table.)

Schedule of Fees.—The schedule of fees may be classified as follows:

I. Per Diem Charge or Rate.
II. Fixed Fee.
III. A Percentage of the Cost for Various Stages of the Work Depending upon the Cost of the Project.

Schedule I, Per Diem Charge—Charges for all classes of work under "A" may be placed on this basis. The amount of the charge should vary according to the character, magnitude or importance of the work or subject involved or according to the experience and reputation of the engineers. This charge should vary from $50 a day upwards and it may be considered legitimate to charge a retainer fee of $250 or more. An additional charge should be made for all actual expenses, such as traveling and general office expense, field assistants and materials used, with a suitable allowance for indeterminate items, plus a profit on this portion of the work of at least 25 per cent over and above all expenses as above enumerated. In such cases when doing office work 8 hours shall be considered to be a day, but when absent from the city each day of 24 hours while away from the office shall be considered a day, regardless of the actual time spent on the work. This includes all days in travel going to and from location of engagement. Payment for services shall be made monthly as the work progresses or upon submission of report or upon completion of work as it is outlined in the contract.

Schedule II, Fixed Fee.—In lieu of the per diem charge as set out under Schedule I, a fixed total sum for services may be agreed upon. In determining this fee, however, the per diem charge plus expenses should be figured as closely as possible, with a reasonable allowance for contingencies. It may be considered legitimate to charge a retainer fee. Payment for services shall be made monthly as the work progresses or upon submission of report or upon completion of work as outlined in the contract.

Schedule III, a Definite Percentage of the Cost.—Charges for work as set out under "B" may be made on a percentage basis according to the table printed at the bottom of page four.

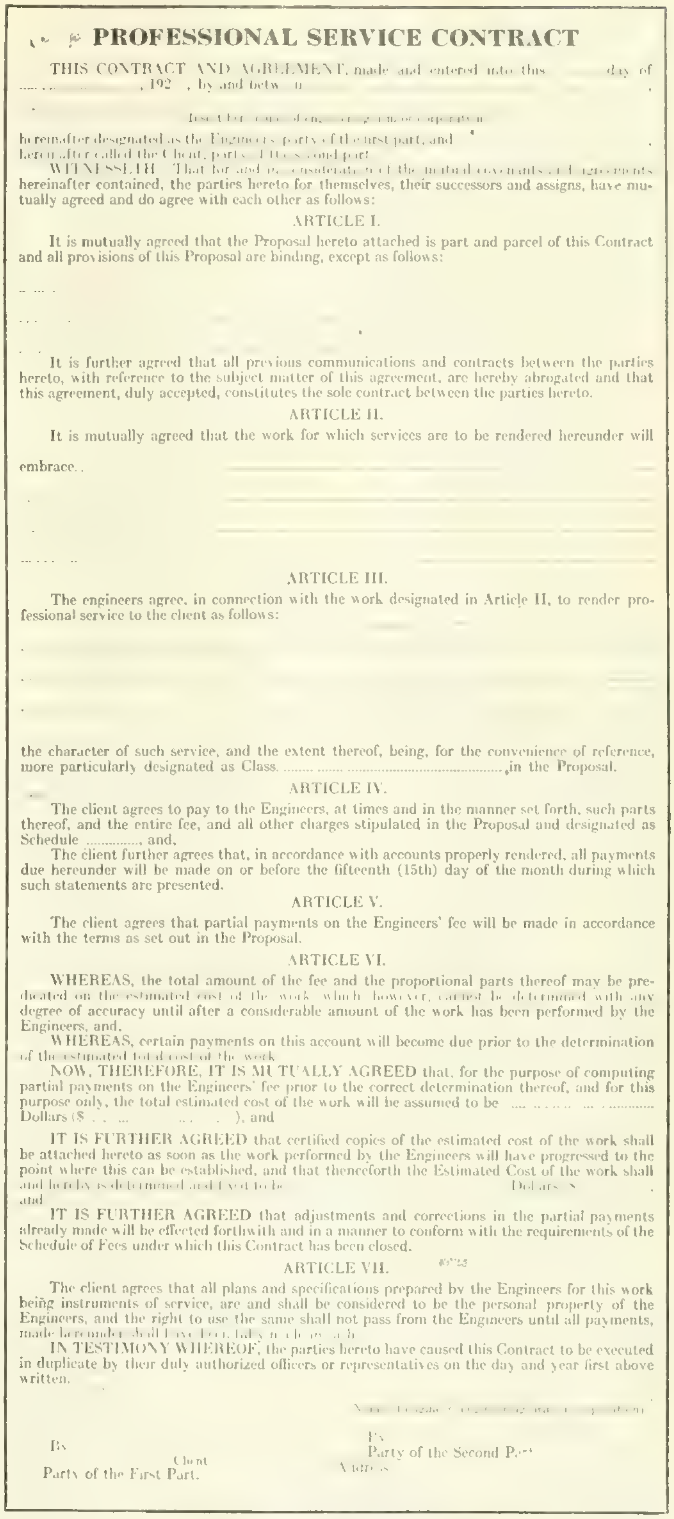
The percentages in the above table are to be computed upon the entire cost of the completed work exclusive of legal and engineering, or upon the estimated cost pending execution or completion.

The term "cost of work," as used, refers only to such part or parts of the whole work or project as the engineers may be engaged to deal with in any of its stages.

Payment for services shall be considered due and payable monthly on account as the work progresses.

General Provisions.—1. Upon undertaking engagement a written contract should be entered into stating as fully and clearly as practicable the conditions of the engagement, services to be rendered and amount or rate of compensation. (There are printed herewith forms of proposal and agreement covering engineering work of various classes which have been largely modeled after those of Mees & Mees, engineers of Charlotte, N. C. These cannot always the used verbatim but can be changed in minor details to fit the particular project.)

2. When alterations or additions are made to contracts, drawings or specifications, or when services are required in connection with negotiations, legal proceedings, failure of contractors, franchises or rights-of-way, a charge based upon time in office and field and all overhead expense should be made in addition to the percentage fee agreed upon as in case of B-1 and B-5 of the table.



PROFESSIONAL SERVICE CONTRACT

THIS CONTRACT AND AGREEMENT, made and entered into this .... day of ...., 192 , by and between ....,

Insert here name of engineer, firm or corporation

hereinafter designated as the Engineers, party of the first part, and ....,
hereinafter called the Client, party of the second part.

WITNESSETH: That for and in consideration of the mutual covenants and agreements hereinafter contained, the parties hereto for themselves, their successors and assigns, have mutually agreed and do agree with each other as follows:

ARTICLE I.

It is mutually agreed that the Proposal hereto attached is part and parcel of this Contract and all provisions of this Proposal are binding, except as follows:

It is further agreed that all previous communications and contracts between the parties hereto, with reference to the subject matter of this agreement, are hereby abrogated and that this agreement, duly accepted, constitutes the sole contract between the parties hereto.

ARTICLE II.

It is mutually agreed that the work for which services are to be rendered hereunder will embrace..

ARTICLE III.

The engineers agree, in connection with the work designated in Article II, to render professional service to the client as follows:

the character of such service, and the extent thereof, being, for the convenience of reference, more particularly designated as Class.......................................,in the Proposal.

ARTICLE IV.

The client agrees to pay to the Engineers, at times and in the manner set forth, such parts thereof, and the entire fee, and all other charges stipulated in the Proposal and designated as Schedule ...., and,

The client further agrees that, in accordance with accounts properly rendered, all payments due hereunder will be made on or before the fifteenth (15th) day of the month during which such statements are presented.

ARTICLE V.

The client agrees that partial payments on the Engineers' fee will be made in accordance with the terms as set out in the Proposal.

ARTICLE VI.

WHEREAS, the total amount of the fee and the proportional parts thereof may be predicated on the estimated cost of the work, which, however, cannot be determined with any degree of accuracy until after a considerable amount of the work has been performed by the Engineers, and,

WHEREAS, certain payments on this account will become due prior to the determination of the estimated total cost of the work,

NOW, THEREFORE, IT IS MUTUALLY AGREED that, for the purpose of computing partial payments on the Engineers' fee prior to the correct determination thereof, and for this purpose only, the total estimated cost of the work will be assumed to be .... Dollars ($.............), and

IT IS FURTHER AGREED that certified copies of the estimated cost of the work shall be attached hereto as soon as the work performed by the Engineers will have progressed to the point where this can be established, and that thenceforth the Estimated Cost of the work shall and hereby is determined and fixed to be .... Dollars ($...........), and

IT IS FURTHER AGREED that adjustments and corrections in the partial payments already made will be effected forthwith and in a manner to conform with the requirements of the Schedule of Fees under which this Contract has been closed.

ARTICLE VII.

The client agrees that all plans and specifications prepared by the Engineers for this work being instruments of service, are and shall be considered to be the personal property of the Engineers, and the right to use the same shall not pass from the Engineers until all payments, made hereunder shall have been fully made in cash.

IN TESTIMONY WHEREOF, the parties hereto have caused this Contract to be executed in duplicate by their duly authorized officers or representatives on the day and year first above written.

Name of engineer, engineering firm or corporation

By
Client
Party of the First Part.

By
Party of the Second Part
Address

Form of Contract for Professional Service.

3. In case of abandonment or suspension of the work at any time, an adjustment of the fee shall be made on the same basis as that of the partial payments or by application of the per diem rates for all work done previous to notifica-

TABLE OF PERCENTAGE FEES FOR ENGINEERING SERVICES.

	Estimated Cost of Project in Dollars										
Service classification....	$10,000 to 25,000	$25,000 to 50,000	$ 50,000 to 100,000	$100,000 to 200,000	$200,000 to 300,000	$300,000 to 500,000	$500,000 to 750,000	$ 750,000 to 1,000,000	$1,000,000 to 1,500,000	$1,500,000 to 2,000,000	$2,000,000 and up
B-1 Surveys—	Actual Cost Plus 25 Per Cent and Upwards.										
B-2 Preliminary Reports......	$2.25	$1.75	$1.20	$0.80	$0.70	$0.60	$0.55	$0.50	$0.45	$0.40	$0.40
B-3 Plans and Specifications..	5.00	4.50	3.75	3.25	3.00	2.75	2.65	2.60	2.55	2.50	2.50
B-4 General Supervision..... ..	[illegible]	1.90	1.70	1.50	1.40	1.35	1.35	1.25	1.20	1.15	1.10
Total B-2, B-3, B-4.........	9.25	8.15	6.65	5.55	5.10	4.70	4.50	4.35	4.20	4.05	4.00
B-5 Resident Supervision-	Actual Cost Plus 25 Per Cent and Upwards.										
B-6 Purchasing	[illegible]	$1.80	$1.35	$1.00	$0.90	$0.85	$0.80	$0.75	$0.70	$0.70	$0.65
B-7 Management	[illegible]	5.00	4.30	3.50	3.00	2.75	2.55	2.45	2.35	2.25	2.15
Total B-6, B-7.... .	[illegible]	6.80	5.65	4.50	3.90	3.60	3.35	3.20	3.05	2.95	2.80

tion of abandonment. These rates and their application are set forth in schedule I and the general provisions applicable thereto. Engineers should keep their records in such a manner that such cost may be accurately determined.

4. When services are required other than those reasonably to be expected for proper fulfillment of the contract, per diem charges may be made, if the work involved be of sufficient magnitude, in addition to the percentage fees provided for. The following are some of the services falling outside of the scope of "ordinary engineering service" such as is contemplated under a percentage contract unless management of project is included:

a. Alterations of convenience after the general plans have been approved by the client and after preparation of detailed plans is under way. (To be paid for on same basis as B-1 and B-5 of table.)

b. Additional work caused by failure of contractors to fulfill their contracts. (To be paid for on same basis as B-1 and B-5 of table.)

c. Services required in connection with legal proceedings, franchises, purchases of property, securing rights-of-way, introduction of accounting systems, preparation of forms for the conduct of the business, establishment of rates and closing of contracts for power, organization of construction forces or operating personnel. (To be paid for on same basis as B-1 and B-5 of table.)

5. Engineers may with propriety undertake all the work in connection with the project, including business, legal and other matters, in which case the fee shall be the subject of special agreement.

6. It should be recognized that in any project undertaken by an engineer there may be many problems requiring the services of a specialist. Testing and inspection of materials at factory or plant shall be construed as coming within this class. The cost of such specialist shall be paid by the client or owner.

7. Drawings and specifications by any method of payment for services are to be considered the property of the engineer but the client is entitled to receive a reasonable number of complete records of the same. All other copies shall be paid for by the client on basis of actual cost of making such copies.

8. It is for the best interests of the client or owner that the engineer be given full direction of the work during the construction period, or, if this is impracticable, that the client employ experienced inspectors approved by the engineer and working under his general supervision.

"Cost Plus" on Preliminary Work.—The surveys and investigations necessary for the preparation of a preliminary report, estimates of cost, and the drawing up of plans and specifications, should be conducted in the most thorough manner possible, and upon such rests the success of the entire project. It is not possible to determine, except in a very few cases, what the cost of these surveys and investigations will be. Therefore, to enable the engineer to give his client the best service and to enable the client in turn to receive the advantage of such, this class of work should be paid for on the basis of actual cost of all field and office expenses plus a definite percentage of profit for the engineer. Resident supervision of construction work should be handled on the same basis. On every piece of construction work there are many delays—sometimes caused by the client who makes changes in the plans or is hampered by financial troubles. Sometimes the contractor either is at fault by poor management or is unable to obtain labor and materials. These delays not being caused by the engineer, should not be charged up to him and it is not reasonable to expect him to pay for the extra expense of supervision and inspection. The client, therefore, should pay for such resident supervision and inspection, and being the one who holds the money and pays the bills, in case of failure of the contractor to comply with the terms of his contract he is in position to protect his interests and those of the engineer.

The public has been somewhat educated to the 5 per cent fee on construction work but applies it only to the smaller projects, demanding a reduction for those projects running into the higher amounts. The fact is that where inspection and resident supervision are included an engineer can not do his work properly, serve his client and make a reasonable profit for such a fee except in those projects which run into the large figures, say, $1,000,000 and above. Like the bricklayer's dream of "8 hours work, 8 hours of recreation, 8 hours of rest and $8 a day" (these proportions have long since ceased to exist), the engineer has looked upon a 5 per cent fee as the Utopia to be attained—but, as in the case of the bricklayer, times have changed.

Coal Tar Coating for Metal Irrigation Flumes

Cool tar has proved an effective medium for coating metal flumes on the Uncompahgre Irrigation Project of the U. S. Reclamation Service, according to a report of F. D. Pyle, formerly project manager, in the November Reclamation Record. His statement follows:

In the fall of 1917 and spring of 1918 a number of flumes were treated by applying a coat of water gas tar followed by a coat of coal tar thinned with water gas tar. This made considerable extra work, and in a number of cases the coating was too thin, either running to the bottom of the flume or checking and cracking on the side of the flume exposed to the sun. Since the summer of 1918 coal tar has been used without thinning, with very good results. The best results have been obtained when tar was applied before the flume had been used more than one season and when tar was applied in warm weather. When applied in cold weather it would not stick to the metal, but blistered and peeled. In tarring flumes it was found essential to clean the surfaces thoroughly, removing all rust from the sheets and from the joints, and to have them perfectly dry and free from dust. The tar was applied hot with heavy brushes or burlap swabs.

Conditions indicate that the joints should be retarred every fall, and the entire flume every other fall. On account of the long irrigation season, it has been difficult to tar as large a proportion of flumes each year as would be most advisable. The tar coat fails by drying, checking, peeling, and blistering. In some cases there is a tendency to erode from the bottom, especially where gravel is carried by the water. a heavy coating of coal tar has proven to be the best method of protecting the flumes when properly applied. In tarring 502 lin. ft. of No. 204 flume, 550 gal. of tar were used, or 0.58 gal. per square yard. The labor and material cost was 21 ct. per square yard. An extra heavy coat was given this flume.

One Year's Fuel Requiments of the United States.—In a paper presented at the recent annual meeting of the American Society of Mechanical Engineers, Prof. L. P. Breckenridge gave the following interesting table to show one year's fuel requirements of the United States and their coal equivalents (13,000 B.t.u.).

Kind of fuel.	One year's fuel consumption	Approx. coal equivalent (Tons, 2,000 lb.)	Conversion factors.
(1) Peat	25 thousand tons	12,500	2 tons = 1 ton coal
(2) Natural gas..	800 billion cu. ft	27,000,000	30,500 cu. ft. = 1 ton coal
(3) Wood	80 million cords	40,000,000	2 cords = 1 ton coal
(4) Water power.	7.5 million developed water horsepower	55,000,000	33 per cent load factor 5 lb coal per hp.
(5) Petroleum .	360 million barrels	100,000,000	3.6 bbl. = 1 ton coal
(6) Coal	650 million tons	650,000,000	....
Total	....	872,012,500	

Entertainment Feature of Chicago Good Roads Convention.—An important feature of the convention of the American Road Builders' Association, to be held Feb. 9 to 12 at the Coliseum, Chicago, will be the entertainment of those attending. The City of Chicago alone has appropriated $15,000 for this purpose. One part of this will be a mass meeting and smoker to be held on the evening of Feb. 9. The program for this includes the following: Musical Program, Chicago Band, William Weil, Director; address of welcome on behalf of the state of Illinois, Honorable Len Small, Governor of Illinois; musical program, Glee Club, Chicago Chamber of Commerce or Hamilton Club Chorus; address of welcome on behalf of the City of Chicago, Honorable William Hale Thompson, Mayor of Chicago; response on behalf of the American Road Builders' Association by Michael Faherty, President. "Good Road Movies."

Annual Meeting of Indiana Engineering Society.—The 41st annual meeting of the Indiana Engineering Society will be held at the Claypool Hotel, Indianapolis, Ind., Jan. 27-28. Charles Brossman, 1503 Merchants Bank Bldg., Indianapolis, is Secretary.

Operation of a True Siphon on a Main Supply Pipe

True siphons in water works practice are of very rare occurrence, and few if any records have been published of their operation. A paper by Wallace R. Braun, Superintendent of Water Works, Hallowell, Me., and Charles W. Sherman, Consulting Engineer, Boston, Mass., presented Nov. 10, before the New England Water Works Association, should therefore be of particular interest. The paper, an abstract of which follows, describes the conditions encountered in operating such a siphon on a main gravity supply pipe.

A supply of water for Hallowell, Me., was originally obtained from the head waters of Cascade Brook, about 1.5 miles northwest of the city. Two small reservoirs were constructed on the brook, and a 6-in. pipe laid from the lower reservoir to two distribution reservoirs just west of the built-up portion of the city. The intake in the reservoir is approximately 8 ft. below spillway level. The pipe leads from the reservoir across a valley perhaps 40 ft. lower, and then rises, crossing a ridge at a distance of about 6,000 ft. from the reservoir. The elevation of the surface here is approximately 9 ft. above the high-water level in the reservoir, and the pipe is about 3 ft. above high water. From this point the pipe descends sharply to distribution reservoirs which are about 41 ft. lower than the supply reservoir.

The portion of the ridge lying above the elevation of high water in the reservoir is 500 or 600 ft. in length, measured along the pipe, and it would have been necessary to excavate at least this length of trench in rock, to locate the pipe below the hydraulic grade line.

Hallowell is a city of about 3,000 population, located on the west bank of the Kennebec River, just south of Augusta. The water consumption is not definitely known, but probably approximates 200,000 to 225,000 gal. daily.

The drainage area from which the supply is obtained covers only about ¼ square miles, and the quantity to be obtained from it, particularly in dry years, is therefore somewhat less than the consumption of the city. Some years ago an emergency connection was made with the pipes of the Augusta Water District, and after a time the operation of the siphon became so unsatisfactory that the entire supply was taken from Augusta. This was the condition in the year 1918 (until December 15), during which year an average of 210,000 gal. per day was purchased from Augusta, at a price of 7 ct. per 1,000 gal., the total bill for the year being $5,367.

Prior to its practical abandonment the method of operating the siphon was as follows: Valves at the inlet and discharge ends of the supply pipe were closed; the air valve at the summit was opened, and a supply water from a small reservoir 20 or 30 ft. higher in elevation was drawn through a 2-in. pipe into the 6-in. pipe to charge the siphon. When all the accumulated air had been expelled at the summit, the air valve was closed and the supply cut off from the upper reservoir; the gates at the inlet and discharge ends of the pipe were opened, and the siphon would operate without attention until a sufficient quantity of air had accumulated at the summit to break the siphon. The efficiency of the siphon began to decrease almost immediately and gradually fell off until the flow practically ceased. It was the custom to manipulate the valves at 7 and 11 a. m. and 4 and 7 p. m., and under this scheme the siphon was operated with a fair degree of success. The consumption of water at that time is not known, but was probably less than at present.

The connection with the Augusta supply was installed primarily to supplement the inadequate supply from Hallowell's own source. The 2-in. pipe from which the supply for filling the pipe was obtained finally gave out and the siphon could not then be operated, and the whole supply was obtained from Augusta, as above noted. The annual expense of obtaining water in this way was so great that the question of replacing the 2-in. pipe or finding some other method of operating the siphon was raised, and Metcalf & Eddy, Consulting Engineers, of Boston, were asked to advise the Water Commissioners in this matter.

The development of the Hallowell water supply had already been made. The water was of excellent quality, but was running to waste for want of a method of utilization, while at the same time the city was paying considerable sums for water to supply this lack. The cost of excavating in rock to lower the pipe over the summit below the hydraulic grade line was practically prohibitive. It was suggested that if some automatic means could be provided by which air could be removed from the summit as it accumulated, there was no reason why the operation of the siphon should not be made continuous and the city's source of supply utilized to its full capacity. An electric power line crossed the summit in close proximity to the pipe, so that electric power was readily available, and there was no reason to doubt the practicability of providing an automatically controlled air pump for the removal of the air. No definite information as to the quantity of air to be handled could be obtained. From the fact that the siphon had been operated with a fair degree of success when operating the valves at intervals of 4 or 5 hours, it seemed obvious that the accumulation of air could not be very rapid. The matter was taken up with Mr. C. O. Rogers, Engineer for the Charles J. Jager Co., of Boston, who suggested the following equipment for this installation:

1 Receiver 24 in. in diameter by 36 in. in length, of reinforced steel construction, with supporting cradles and 6 in. flanged yoke,
1 Water glass and fittings for indicating water level in the float chamber,
1 Copper deposit float with necessary connections for the operation of float switch,
1 Triple pole float switch of the enclosed type.
1 Gardner compressor unit, 3x3½, air cooled, with extended motor base and belt and idler drive. Capacity of compressor 8 cubic feet of free air per minute,
1 1½ h.p. 3-phase motor, 1,800 r.p.m. for 220-volt current.

After some consideration order was placed with the Jager Co. for this apparatus.

A vault 12 ft. long, 6 ft. 6 in. wide and 8 ft. deep, was built enclosing the pipe at the summit, where a Tee-branch was set, turned up. The air tank or receiver was mounted upon this Tee and a small wooden building previously located over the air valve, was placed over the entrance to the vault. Considerable rock excavation was involved in this construction. The total cost of the installation is estimated as follows:

Pumping equipment, including air tank, etc.	$ 643
Vault, about	800
Installation and connection of apparatus, about	100
Total	$1,543
Say	1,600

The apparatus was put in operation on Dec. 15, 1918, and has been in practically continuous service ever since. The motor operating the pump was burned out some time later, due to a drop in voltage on the electric power line, and through no fault of the apparatus. The operation is entirely automatic and the siphon is maintained in continuous operation. It is, of course, necessary to throttle the valve at the discharge end of the supply pipe where it enters the distributing reservoir, in order to prevent breaking the siphon, due to the excessive drop in this leg of the siphon, and also to avoid depleting the rerservoir too rapidly.

It is still necessary to obtain water from Augusta to supplement the inadequate supply from the local source, particularly at times when the consumption is high. During the year 1919 an average of 84,000 gal. per day was so obtained, at a cost of $2,146. During this same year the cost of electric power for operating the vacuum pump was $85, the price being 9 ct. per kw. hr., and in addition the cost of electric lights for the vault was $9, making a total cost of electric current $94. If interest and depreciation on the investment be assumed at 7 per cent or $112 per year, the total cost of operating the siphon during 1919 was $206. Adding this sum to the cost of water purchased during that year, makes the total cost of the water supply $2,351, or $3,015 less than the cost for the year 1918.

A similar comparison for the first six months of 1920, is as follows:

Cost of water bought from Augusta (110,000 g.p.d.)	$1,396
Cost of electric current	66
Interest and depreciation	56
Total (for 6 months)	$1,518

or $3,036 per year, which indicates a saving of $2,331 for 1920 as compared with 1918.

When the apparatus was first installed, the pump operated only about once an hour. It was found, however, that at times when the water in the reservoir is comparatively low, much more air accumulated, and in July of this year the pump was found to be operating about once in 5 minutes. The difference in water level in the receiving tank, between the time of starting and stopping the pump, is about 6 in., corresponding to an accumulation of air of approximately 3 cu. ft.

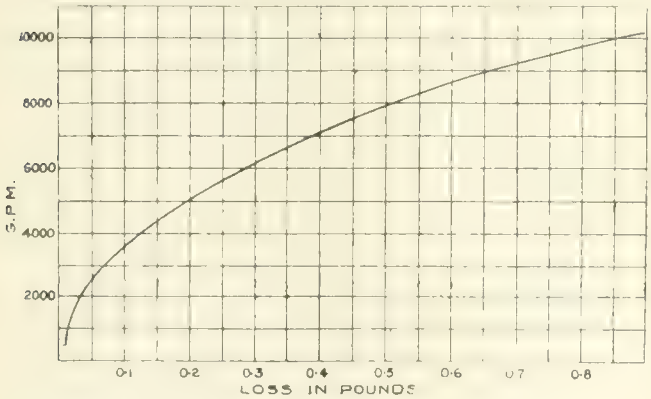
It is probable that when the water in the reservoir is low, more air enters the pipe at the inlet end in solution or in suspension in the water, and it is also possible that some air is drawn in by vortex action. The period of low water in the reservoir also corresponds to the time of low ground water, when a greater amount of the pipe which is below the hydraulic grade line, and therefore subject to negative pressure, is below ground water level. Under these circumstances more air would probably be drawn into the pipe, through joints, than when ground water is high.

The pump maintains a vacuum of approximately 21 or 22 in. of mercury, corresponding to about 24.5 ft. of water. The hydraulic grade line at the siphon is therefore about 24.5 ft. below the pipe at the summit of the siphon, and 20 or 21 ft. lower than the water in the reservoir.

Loss of Pressure Due to Placing 12-In. Gate in 16-In. Pipe and to Partial Closure of Gate*

By THOS. E. LALLY,
Assistant Engineer, Water Department, Boston, Mass.

The writer has not found any extensive tests recorded on the loss of pressure caused by the placing of a gate or valve of smaller diameter, with suitable reducer and increaser, in a pipe line of larger diameter. Therefore such information as has been obtained in Boston may prove of value to engineers and superintendents having to do with the construction and maintenance of water systems.



Loss Through 12-In. Gate with Reducers in 16-In. Line.

The statement has often been made that if a smaller valve could be placed in the line without too much pressure loss, time could be saved in case of a break. In Boston it is very hard—almost impossible—to put a line-size gate in any of the feeder lines, because of the crowded condition of the underground street area due to public service equipment. Therefore it was thought desirable to determine the actual loss if possible.

Tests at Boston.—The tests were made with a 12-in. gate placed between two 16 by 12-in. reducers in a 16-in. line. The gate and reducers were of the Boston Waterworks standard. No selection was made and no extra care was taken with the castings. In fact, they were simply taken from stock and placed in the line.

The test line was prepared by cutting in a 12-in. gate on a 30-in. low-pressure feeder-line. From this gate a 12-in. line was extended to the street line, where it was brought to the surface by easy curves and continued on blocking so that the bottom of the pipe was about 6 in. from the ground. The line was extended by putting in a 12 by 16-in. increaser and then 16-in. pipe for a certain distance, when a 16 by 12-in. reducer and a 12-in. gate with a 12 by 16-in. increaser were set. The pipe was then 16 in. for a certain distance, where a 16 by 12-in. reducer and a 12-in. gate were introduced. Then the line was continued with 12-in. pipe to a curve and a special casting, with a flange, increasing to 14-in. internal diameter. To this casting was attached a bronze forebay to which it was possible to attach nozzles from 8 in. down to 2½ in.

The 16-in. pipe was bored, just outside each reducer, by ⅓-in. holes through the walls of the pipe, 120° apart, with one hole on the vertical diameter. These holes were then bored out part way through the pipe and tapped for ¼-in. iron pipe. Care was taken to remove any burr on the interior of the pipe and to see that the holes were on radial lines and at right angles to the pipe. As will be noted, there was no chance for the ¼-in. pipe to enter the waterway, and consequently no disturbance was caused by these connections. Pieces of ½-in. hose were attached to the lower ¼-in. pipes and both were brought together into a ¼-in. cross at the top holes. This cross was connected by ½-in. hose to a valve board which had a number of ¼-in. valves, which were connected to a long U-tube with a suitably graduated scale. Both pipes were measured at these holes and found to be 16.01 and 16.03 in. It was not considered that this difference would have any noticeable effect on the results, and both pipes were considered of the same diameter and used as piezometer rings.

Carbon tetrachloride, having a specific gravity of 1.60, was used to act as an indicator in the U-tube. Mercury might have been used, but as the loss expected was small and the specific gravity of mercury is about 13.56, it will be seen that the carbon tetrachloride is 11 times more sensitive and small differences in pressure would give greater deflections in the U-tube. The tube and lines of hose were provided with blow-off cocks and care was taken to lead the water upward to these so that air in the lines could be blown out. The difference in pressure, before entering the reducer and after leaving the increaser attached to the 12-in. gate, was caused to be shown in the U-tube, and by the use of a factor explained later, the actual loss in pounds was arrived at.

The forebay was bored on the ends of two diameters at right angles to each other, and these holes were connected to gage fittings on the top by bronze tubes. The interior was of piston finish, as were the nozzles. The reducing portion of the forebay, from 14 to 8 in., was very gradual. The 8 reduced to 6 in. by a bolted fitting. The other reductions were made by screw nozzles, reducing one to another by inches, so there was a gradual reduction from the 14-in. forebay to the 2½-in. nozzle without any breaks in the interior wall of the waterway.

The flow was controlled by the last 12-in. gate, thereby keeping the gate under test always full of water. This control gate was operated by a hand-wheel and any pressure desired could be obtained in the forebay within the range of the nozzle used. From pressure readings on the forebay gage, after corrections for the height of the gage over the center of the nozzle, the discharge was calculated by the use of Freeman's formula. Readings on the gage and the difference on the U-tube were taken simultaneously, and from these readings it was possible to know the discharge and the loss for any flow up to the capacity of the nozzle. When the pressure in the forebay did not increase on the wider opening of the control gate, it was assumed that the capacity of the nozzle had been reached.

The next larger nozzle was then used and by the control gate the full range of the discharge was run. In this way discharges from 700 g.p.m. to over 10,000 g.p.m. were obtained and losses through the gate were measured. During all these runs the gate under test was always wide open.

The available static pressure on the line at the gate being tested was 57 lb. It must not be assumed that the results here given are to be applied to every gate of this size. This test was on a standard gate of the Boston Water Works, and tests on gates of other design would probably give slightly different results. This gate is considered of good design. There are no obstructions in the waterways; the plug and stem are out of the waterway when full open.

Results of Tests.—The results of the tests have been plotted and it will be seen that the curve does not follow the mathematical curve for losses. This rule, that "the loss in friction is as the square of the discharge," while near enough for practical purposes, does not obtain in these tests. This caused a feeling that there was something wrong in the first test, and other tests were run, special care being taken to get the air all out of the lines and the connections tight in every way. The results agreed with the first and the writer began to look for the reason.

It was found that the plotting of the curve on a large scale

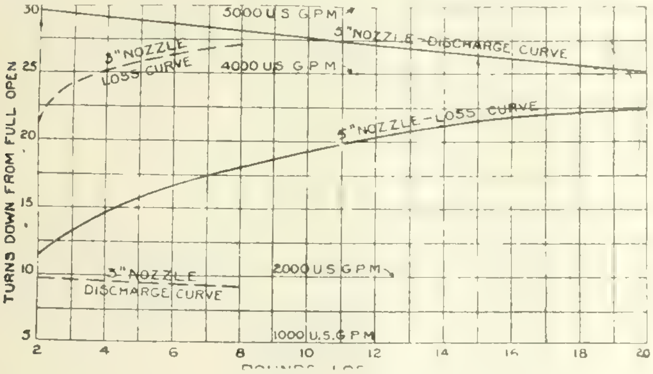
[illegible]

caused the difference to stand out; and while it was small, it looked large on the plot. As far as the writer knows losses due to such large flows through a gate of this size had never previously been recorded. Then, taking Freeman's paper, "Hydraulics of Fire Streams," and analyzing some of the tabulated data, it was found that the loss did not vary as the square but ranged from 1.775 to 1.92, and Freeman in the same paper says that his results do show that "there is a slight divergence from the law." Referring to Flinn, Weston and Bogert, "Waterworks Handbook," 1916 edition, page 560, it reads: "Text books make the general statement that the friction head in pipes varies nearly as the square of the velocity. Researches indicate that this exponent varies between 1.75 and 2.00."

A. V. Saph and E. W. Schoder presented a paper to the American Society of Civil Engineers in 1903 on investigation of the losses in pipes from a velocity of a fraction of a foot per second to 44 ft. per second, and their plottings show different exponents for different kinds of pipe, but the exponent is evidently the same for each size of the various kinds at each velocity.

The velocities, in the 12-in. gate under test varied from 1.3 ft. per second, discharging 750 g.p.m., to 34 ft. per second at 12,000 g.p.m. With these differences in view, the writer felt that the fact that the curve did not agree with the curve of the squares was not due to errors in the methods, gage connections or readings.

The 14-in. forebay used in these tests slowed up the velocity of the water before entering the nozzles, and the gage on the forebay showed a very steady pressure, there being a noticeable absence of the vibrations such as are shown in the piezometer tubes placed at the base of play pipes in flow tests made on lines of fire hose. The writer first figured the data with seven place logarithms, and finding that the results could be obtained by the slide rule to two places of decimals, used the rule for the greater part of the calculations. As we are dealing with hundredths of a pound loss, with a maximum of about a pound total loss, it did not seem necessary to resort to the longer method.



Loss Caused by Partially Closing 12-In. Gate.

In calculating the discharge from the pressure in the forebay, a correction was made for the elevation of the spring gage over the center of the nozzle. The discharge for 4 lb. and 64 lb. were calculated and plotted on a large sheet of logarithmatic tracing paper making a straight line between from which, with any pressure on the forebay with the size of nozzle discharging, the discharge was read off on the paper. This was done for each size of nozzle used and greatly facilitated getting the data from which the curves were made.

In using carbon tetrachloride as an indicator, as the writer stated before, the deflection or difference in height of the tops of the column of fluid in the arms of the U-tube is over eleven times as great as it would be if mercury were used. This, however, introduces a condition that requires attention.

In a difference of 1 lb., using mercury, the measure of this in inches is about 2 1/32 in. With tetrachloride, being only 1.6 heavier than water, the difference ought to be about 17¼ in., as the weight of, or pressure due to, a head of water 27¾ in. in height is one pound. However, as the fluid drops in one arm it rises in the other and water takes its place on the pressure side until a balance is obtained. Now, instead of reading the true difference in pressure, we have a column of water on one side greater in height than that on the other, or low pressure arm, by the difference in height of the tops of the fluid in the tube. The weight of this column of water must be subtracted from the indicated difference in pressure to arrive at the true difference. The difference, when using mercury, is slightly over 2 in. for 1 lb. difference in pressure, and with mercury, under ordinary circumstances and unless dealing with large losses, may be neglected; but with such a height of water column, when using an indicator of such low specific gravity, a correction must be made for each difference in pressure.

Obtaining True Pressure.—The writer found that a factor could be obtained by the use of which the true pressure could be arrived at with very little work. As the scale on the U-tube was graduated for the use of mercury, it was found that by multiplying the reading on the mercury scale for pounds and tenths of pounds by 0.044, the true difference in pressure for the specific gravity of 1.60 was obtained. This factor would change if the specific gravity of the indicating fluid were changed. With a tube that would give a difference of pressure of 30 lb. mercury, or about 6 ft. long, the tetrachloride would give a difference of pressure of about 1.32 lb. However, as a small loss was looked for, this indicator proved satisfactory.

The writer found that great care had to be exercised in the use of this indicator. The first runs were marred by irregularities in the readings which were found to be caused by air in the rubber hose connections. After having found the cause great care was taken to keep the hose free from air, and the results began to agree, one test with another. Tests were run on six different days and the writer feels that the results given are very close to the actual conditions.

With a flow of 500 g.p.m. the loss was 0.01 lb.; at 1,000 g.p.m. it was scarcely larger; at 2,000 g.p.m. about 0.03 lb.; 4,000 g.p.m. about 0.12 lb.; 5,000 g.p.m. about 0.2 lb.; 6,000 g.p.m., 0.29 lb.; 8,000 g.p.m. about 0.51 lb.; 10,200 g.p.m., 0.92 lb.

These losses make a curve, when plotted to suitable scale, and show clearly that we may place this smaller size gate in our pipe lines and not lose over one pound pressure with a discharge which would seldom be required even in a 16-in. line.

Loss Due to Partial Closure of Gate.—The writer thinks that in addition to the information already given, it would not be out of place to add a little in another line that he obtained while making these tests.

The indicator was drained out from the U-tube and mercury substituted. With the same set up of the U-tube and a 5-in. nozzle on the forebay, the control gate was opened full, getting a discharge of about 5,000 g.p.m. The writer then caused the gate under test to be started down, carefully noting the turns taken and watching the U-tube until the mercury showed 1 lb. loss. It was found that the mercury gave 0.2 lb. loss with this discharge with the gate open full, as it had been when the flow tests were made. When the gate had been closed 9 turns the loss was 1 lb.; 11¼ turns gave 2 lb. loss; 13½ turns, 3 lb.; 14½ turns, 4 lb.; 18 turns, 8 lb.; 21 turns, 14 lb.; 22 turns, 18 lb.; 22½ turns, 20 lb.

This was the limit of the mercury column and no further losses were noted. This gate requires 32 turns to close it fully. During this closing period the discharge fell from 5,000 to 4,050 g.p.m.

The test was then run using a 3-in. nozzle to get a smaller discharge, as the results would probably be more in line with the requirements of a small system. It was found that this gate was passing 1,940 g.p.m. full open with the 3-in. nozzle. The gate was closed down 20 turns before the pressure fell 1 lb., and the discharge was then 1,920 g.p.m.; 25 turns gave a loss of 4 lb., with a discharge of 1,910 g.p.m.; 27 turns gave a loss of 8 lb., with a discharge of 1,830 g.p.m.

Composition and Heating Values of Different Ranks of Coal.—The following table, showing the composition and heating values of different ranks of coal computed on ash free basis, formed a part of a paper presented at the recent annual meeting of the American Society of Mechanical Engineers by Prof. L. P. Breckenridge:

Rank of coal.	Heating value, B.t.u.	Fixed carbon, per cent.	Volatile, per cent.	Moisture, per cent.
Anthracite	14,440	95.6	1.2	3.2
Semi-anthracite	11,880	83.8	10.2	6.0
High-rank semi-bituminous	15,360	83.4	11.6	5.0
Low-rank semi-bituminous	15,480	75.0	22.0	3.0
High-rank bituminous	15,160	64.6	32.2	3.2
Medium rank bituminous	13,880	54.2	40.8	5.0
Low-rank bituminous	12,880	47.0	41.4	11.6
Sub-bituminous	9,720	42.4	34.2	23.4
Lignite	7,100	37.8	18.8	43.4

Conclusions on Construction and Design Features of Concrete Pipe

A study of concrete pipe has been made by irrigation engineers of the U. S. Bureau of Public Roads. The results are given in a professional paper written by Fred C. Scobey, Senior Irrigation Engineer, and issued Oct. 28 by the U. S. Department of Agriculture, as Bulletin No. 852, "The Flow of Water in Concrete Pipe." The conclusions based on facts developed in the investigation are given in the bulletin as follows:

In considering the design of a concrete pipe or conduit, from a capacity standpoint, the fundamentals to be kept in mind are:

(1) Original interior surface.
(2) Engineering; inspection and supervision of construction.
(3) The water.
(4) Acquired interior surface.

In a jointed pipe, the original interior surface depends upon that of the individual units and of the assembled whole. The smoothest units are cast of a wet mixture and allowed to set in rigid, smooth, oiled forms. These units are true to shape and assemble into a nearly perfect pipe. As the joints are practically as smooth as the cast surface, the number of joints is almost immaterial.

Most processes that permit immediate removal of the forms do not protect the plastic concrete against distortion. Distortion in the units means offsets in the pipe that may easily decrease the capacity from 10 to 20 per cent. This percentage may be reduced after assembling the units by tapering down the offsets with mortar applied with a trowel. Supervision of the finished joints will usually improve the capacity materially. The good results obtained with the band method appear perfectly feasible.

A brush coat applied to a rough original interior will increase the capacity and decrease the percolation. The same coat applied to a smooth interior will decrease its capacity and is not needed, under ordinary pressures, to prevent percolation, if the pipe is properly made. This is true for the reason that methods used in making pipe with a smooth interior are also conducive to a dense concrete. The coating may scale off if radically different mixtures are employed for pipe and coat.

Pipe units made with the molds now on the market usually run undersize by as much as 3 or 4 per cent (in area) for diameters under 20 in. Above that size, the nominal and actual areas are more nearly equal. Most pipes made with a wet mixture in short units, from which the molds are immediately stripped, "slump" to a slight extent, making a section somewhat undersize in area with a slight excess in shell thickness.

From a capacity standpoint monolithic pipes and conduits are built under two general conditions: (1) In the open or in the comparative freedom of a trench; (2) in a tunnel. Under the first condition the form adjustment, bracing, supervision, concreting, spading, and final inspection can be conducted from both inside and outside, with the added advantage of working in the daylight. Naturally this tends to result in better workmanship and higher carrying capacity than is feasible in a tunnel where all of the above operations must be done from the inside alone under the shadows and imperfections of artificial lighting.

For all shapes, circular or otherwise, the invert is usually laid first. Forms for the remainder of the section are then placed on the invert and the section completed. Sometimes the first pouring extends just across the bottom and sometimes is carried up to the spring line. This depends on shape and size of the section. Smooth joints between the pourings and between the ends of adjoining set-ups are difficult to attain. Unless very heavily braced, the pressure of the head of wet concrete will spring the forms and result in offsets. On the Catskill aqueduct this amounted to as much as 0.15 ft. There have been cases where contractions of from 2 to 4 in. were made in sections 5 ft. or less in diameter. Other factors that influence this movement are weather, length of sections, rapidity of filling the forms, and the type of aqueduct.

[illegible] rough interior when the forms were stripped and relied on a [illegible] on that of a plaster coat on a certain sized conduit equated against that of an unplastered surface on a larger conduit. The present practice in general is to use smooth steel forms; clean them thoroughly after each casting, then dry and oil or grease them before using again. If close attention is given to spading the mixture into close contact with the forms, then a surface is secured that is smoother than will be attained by adding a plaster coat, local roughness alone being improved by pointing up and chipping down. The crown in particular is liable to be rough.

Experience indicates that a given surface is more assuredly repeated in a pipe of precast sections than of monolithic construction. Thus a smaller factor of safety in the way of capacity overload may be assumed for precast pipe. The experiments indicate that some of the smoothest pipe is of careful monolithic construction; likewise some of the roughest. Thus, while a very smooth surface may be attained, it can not be anticipated with the assuredness possible where units are precast under the best practice and subject to the conditions attainable in a pipe yard.

For all types of pipe, competent engineering supervision and inspection are necessary if the best results are to be obtained. Velocity and entry heads should be provided at the intake. Alignment and grades should be true. Changes in either should be made with as gentle curves as are feasible. Unless it is excluded above the intakes, means should be provided for the removal of debris at the foot of steep upward slopes. Means for the removal of air, not only at the summits but also near the intake (unless deeply submerged) should be provided. This is true of small orchard lines as well as large siphons. Trash racks, originally placed at the intakes of many siphon pipes, have since been emoved in many cases because the danger from washout due to the accumlation of trash, outweighed the good accomplished.

For all practical purposes it does not appear necessary to limit the higher velocities. The velocity should be at least sufficient to prevent the deposition of silt—probably not lower that 3 ft. per second.

More or less slime may be expected from waters stored in reservoirs containing algæ growths or from waters that have been conveyed long distances in openearth channels. This may also be true, but to a less extent, if the open channel is of wood or concrete. Waters of the Southwest are less liable to develop retarding growths in covered conduits than those of the East and Northwest. Water containing calcium carbonate ($CaCO_3$) will smoothly coat pipe of any material. If sand, gravel, or other debris is also present in the water, the cemented accretion will be much more harmful, being rough and more rapid.

After construction a rough pipe may become somewhat smoother if conditions are such that a mineral coating is deposited. An originally smooth surface will remain about as constructed or depreciate slightly by mineral or slime deposits. Slimes come quickly or not at all. A depreciation of from 10 to 15 per cent in capacity can occur within 5 to 7 months, but does not greatly increase after that. Thus, to be of material benefit, cleaning must be frequent if necessary at all. For this reason periodic cleanings have been abandoned in many places. If algæ slimes are anticipated, it may be best to allow for 15 per cent depreciation of capacity and no cleaning.

Work of U. S. Reclamation Service.—The net cost of the reclamation projects to the end of the fiscal year 1919, according to the recent annual report of the U. S. Reclamation Service, was a little less than $125,000,000. The projects now under way or completed embrace approximately 3,300,000 acres of irrigable land and will ultimately provide about 60,000 farms, from 10 to 160 acres each. During the year water was available from Government ditches for about 1,636,000 acres on 39,000 farms, and in addition water was supplied under contract to 1,000,000 acres outside Government projects. Lands served in whole or in part by the Government projects produced crops valued at $150,000,000, of which $89,000,000 represented yields from lands in the projects proper. The crop year of 1920, just closed, in quantity production far exceeded that of 1919, but owing to the slump in values it is believed the total figures will be somewhat less.

Chatham, Ont., Adopts Commission-Manager Form.—At the recent election the city of Chatham, Ont., voted to adopt the commission manager form of city government.

Ice Diversion Works of St. Lawrence River Power Co.

The operation of ice diversion works recently completed in the St. Lawrence River for the St. Lawrence River Power Co. have proven very successful in permitting a considerable increase in their power output during the critical months. The works are the result of a considerable amount of study and experiments carried out under the direction of Benjamin F. Groat, Consulting Engineer, Pittsburgh, Pa., who has described this work in a recent issue of The Canadian Engineer, from which the following is abstracted.

The location of the power company is at Massena in northern New York while the diversion works are in a section of the St. Lawrence which has some very complicated conditions. A general outline map of this region is shown in Fig. 1.

At the head of Croil Island the St. Lawrence River divides into the North and South Channels of the Long Sault Rapids. At the foot of Croil Island a large portion of the water in the South Channel returns to the North Channel down the Big Sny Channel between Croil Island and Delaney Island. At the foot of Long Sault Island nearly all the water in the North Channel returns to the channel south of Barnhart Island. Croil Island, Delaney Island, Long Sault Island and Barnhart Island are all in the United States, while Sheek Island is in Canada, the international boundary lying in the North Channel.

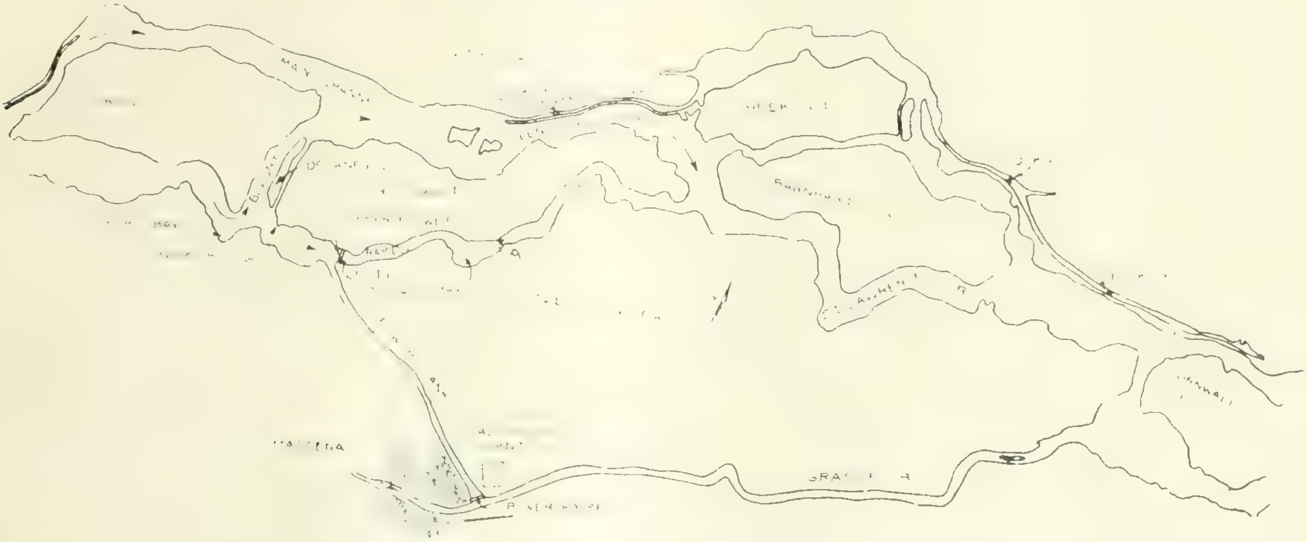


Fig 1.—St. Lawrence River from Croil Island to Cornwall Island.

The water north of Sheek Island is an overflow from the Cornwall Canal, the surface of the water in which is about 25 ft. higher than the surface of the water in the river at the head of Barnhart Island. The principal part of the fall of the North Channel (Long Sault Rapids) is between Lock 21 and the head of Barnhart Island. It amounts to about 25 ft.

In the South Channel, above Dodge's Shoal, the water is several feet higher than it is at the head of Cornwall Canal (Lock 21), owing to the fact that there is a steep slope and rapid water down the Big Sny. There is rapid water at many points along the South Channel from the rapids over Dodge's Shoal to the foot of Long Sault Island, but the total fall will scarcely reach 30 ft. under the most favorable normal conditions of river and channels.

The Massena power canal takes its water supply from the South Channel, about 4,000 ft. below Dodge's Shoal, being assisted by the submerged weir and jetty extending from the main shore to Long Sault Island. The total fall available between Richard Bay and the foot of the Grasse River, via the canal and power-house, is about 50 ft., a large part of which (more than 20 ft. for a liberal canal draft) was lost before the extensive program of dredging for the canal and Grasse River was undertaken by the power company. The loss at present is about 6 ft. in 12 miles of river and canal.

The ice troubles at Massena have been distressing ever since the plant began operation about 20 years ago. Annually, there has been a preponderating shortage of power, frequently amounting to a complete shut-down. Despite mechanical and electrical capacity in the powerhouse for more than 90,000 HP., on many occasions for weeks at a time in winter there was scarcely power for the requirements of the village lighting and water supply, the aluminum plant being completely shut down.

There were two serious causes for these ice troubles. First, river ice was drawn into the canal in such large quantities, during heavy runs of ice, that the canal became jammed and choked until the water supply was practically cut off. Second, jams formed down river, especially at a point just above Lake St. Francis, or at the outlet of Hopson's Bay, in the South Sault Channel.

The jams which form down river build back upstream annually, causing high backwater at the foot of Grasse River. This backwater extends to the power house at Massena, thus reducing the head on the turbines during such periods, sometimes by as much as 10 ft. Upon further accumulation the jam extends back to the foot of the Long Sault, sometimes completely submerging and obliterating the rapids; at such times a skiff might be rowed about on the resulting pond. The jam then may continue up the South Sault to Dodge's Shoal and there completely cut off the supply of water to the South Sault and consequently to the powerhouse.

The jams which form at the outlet of Hopson's Bay also build back to Dodge's Shoal in the same manner and cut off the water supply to the South Sault channel and powerhouse. A jam at any point further down the river may cause similar difficulties.

The principal cause of obstruction was the jamming of the power canal with river ice drawn under the power company's boom across the canal intake. Tests on models, as well as actual experience, show that if ice lodges in sufficient quantity against a boom in deep water having considerable velocity, all ice subsequently drawn to the boom will pass under. Troubles with frazil ice forming on the racks at the power house were of secondary importance, though embarrassing at times. It is the object of the ice diversion works to prevent the entrance of all kinds of river ice into the power canal.

A most careful study of the history of ice conditions at Dodge's Shoal proved that ice seldom or never lodged there or jammed in the shoal water, owing to the high velocity over the shoal. The hydrography of the channels at Richard Bay, in the Big Sny and in the South Sault showed that the water was generally 50 to 55 ft. deep except over the shoals, where it was only 4 to 10 ft. deep with a width fully equal to that of the other channels.

Hence the capacity of the water flowing over the shoals to discharge floating ice is much greater than that of the main channel to deliver ice laterally to the South Sault, so there can be no jam on the shoal as a result of shoal water. The only time that jams rest upon Dodge's Shoal is when they have formed down river and have built back upstream. When they do so the ice jam becomes a veritable ice dam on the shoal, turning practically the entire flow of water with its ice load down the Big Sny.

The ice diversion works consist of a wing dam, patented diversion channels and a boom extending from the crib at the downstream ice diversion channel across Dodge's Shoal to the head of Delaney Island. A submerged weir was placed across just below the canal intake, as indicated in Fig. 1. All of these structures were operated in a more or less incomplete condition during the winters of 1918-9 and 1919-20. The four ice-diversion channels shown in Fig. 2 are about 40 ft. deep in hardpan sufficiently strong to stand on a very steep slope. The ridges between contiguous channels rise from a submergence of 15 ft. at the upstream side of the upstream channel to about 8 or 10 ft. at the downstream side of the downstream channel, the cross-velocity varying from 1 to 2 ft. per second at the inner ends to 7 or 8 ft. per second at the outer, or river, ends. The main channel toward Croil Island is 40 to 50 ft. deep, and the ice-diversion channels run out into it until the bed of the main channel falls below the grade of the bottoms of the ice-diversion channels.

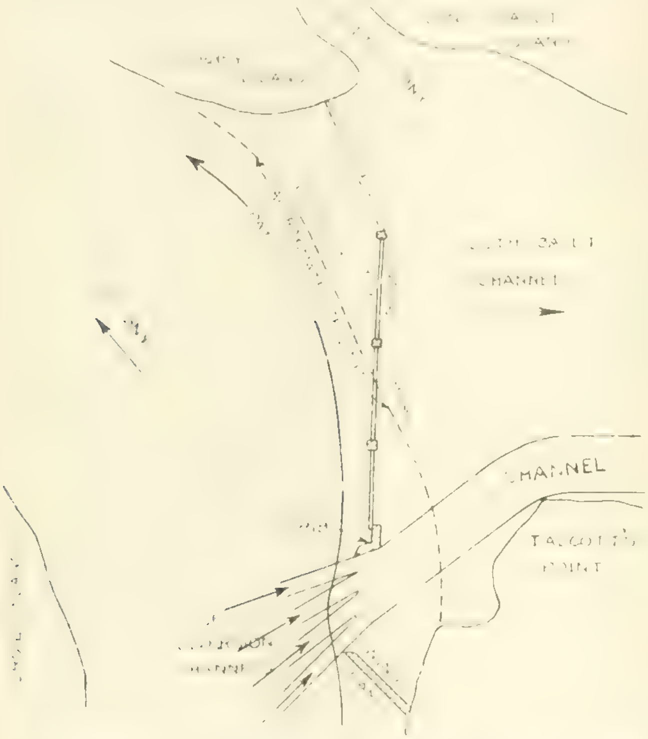


Fig. 2.—Wing Dam, Ice Diversion Channels and Boom Across Dodge's Shoal. Ice Diverted to Big Sny Water Enters South Sault Free from Ice.

The function of the ice-diversion channels and ridges is to throw the surface water with its load of floatage, whether it be ice, weeds or timber, across the channels clear of the boom, while water free from floatage is drawn from the bottom of the river along the bottoms of the channels to the South Sault.

The object of the boom is to create a jam, or ice dam, upon the shoals so as to prevent ice from floating into the South Sault after having been diverted across the ice-diversion channels. The water under the boom varies from 6 to 10 ft. deep, but it is expected that the boom will offer sufficent obstruction to cause the ice to jam ahead of it and build out to the limit line taken by former ice jams as shown in Fig. 2. This is just what occurred during the winter of 1918-9 except that the boom had not been extended completely to Delaney Island, there being a gap of something like 100 ft. left open next the shore.

There were several places where ice was drawn under the boom. The result was that considerable quantities of ice passed into the South Sault Channel, but sufficiently far from the south shore to escape being drawn into the power canal. The boom is composed of a line of heavy scows drawing 4 or 5 ft. of water, and is held in place by means of cribs, as shown in Fig. 2.

The submerged weir is intended to reduce the slope over Dodge's Shoal, for the safety of the boom. This is accomplished by raising the level of the water at the canal intake to reduce the draft under the boom, otherwise the draft would be so strong that ice would be drawn under in large quantities even though the boom could withstand the punishment. The four elements, wing dam, ice-diversion channels, boom and submerged weir form a unit which would not work well in the present situation if any one were deleted.

The following comparison shows the gain in power for the first quarter of 1919 over the average power generated during the first quarters of the preceding 10 years, and over the average of the three power maxima for January, February and March during the same 10 years:

	El. k.w.
10-year average	11,600
Maximum (1915-6)	21,560
Actual, 1919	41,760
Excess, 1919, over 10 year average	30,100
Excess, 1919, over previous maximum	20,200

To determine the gain for December and April, it may be assumed that, as an average, the gain will vary from nothing on Dec. 1 to 30,000 el. k.w. on Dec. 31, and from 30,000 k.w. on April 1 to nothing on April 30. This method of determining the gains for December and April is merely approximate, but is more or less confirmed by the fact that the 30,000 el. k.w. average gain for the first quarter of 1919 was distributed according to the following tabulation:

	El. k.w.
January	29,140
February	31,910
March	29,080
Average	30,000

Therefore there was a gain for the first quarter of 1919 amounting to 90,000 k.w.-months, and for December and April a computed potential gain amounting to 30,000 k.w.-months, or a total for the winter of about 120,000 k.w.-months, which is equivalent to an annual gain of 10,000 k.-w-years.

As aluminum is manufactured at the rate of about 600 lb. per k.w.-year, the equivalent gain in output capacity amounts to about 6,000,000 lb. of metal for the winter of 1918-9, thus showing that the power company has substantially made good its promise to the International Joint Commission that the improvements at Massena would increase the capacity by 6,000,000 or 7,000,000 lb. of metal during the winter.

The ice diversion works operated very successfully again during the winter of 1919-20, which was about the longest and most severe on record. The available power was not much less than the output during the preceding winter, which was mild after January.

The minimum power at Massena during the severest winter should not henceforth fall below 33,000 k.w. If it does, then it is safe to say that someone has failed to learn his lesson.

As regards relief from ice troubles, there can be no doubt of the advantages of ice diversion, but in bad winters there will be some power loss due to the backwater in the tailrace from down-river jams. If future experience should show that a larger percentage of ice must be diverted to give full capacity, there will be no difficulty about increasing the capacity by adding more channels and by making the boom and submerged weir ice-tight, provided the approval of the International Joint Commission be granted.

Providence, R. I., Waterworks Clears $285,000 in 1920.—The waterworks of Providence, R. I., in 1920, after paying all interest charges and setting aside $140,000 for depreciation, returned the city a net profit of $285,000, according to figures contained in the annual report of the City Auditor. In the 50 years of its existence, the waterworks, exclusive of the new Scituate project, has earned $5,635,000 after payment of all charges and establishment of a depreciation fund which now aggregates $1,382,000. Of $10,166,000 in bonds issued at different times for the financing of the present waterworks, all but $1,695,000 have been retired. The auditor's figures show that since its establishment the total receipts of the waterworks from all sources have been $26,178,745, with expenses, exclusive of bonds issued, but including bond interest, amounting to $20,090,476.

Propose Engineers' Registration Law for Ontario.—Professional engineers in Ontario, through the Engineering Institute of Canada, are endeavoring to obtain engineering legislation for the registration of engineers in this Province similar to laws enacted in British Columbia, Alberta, Manitoba, Quebec, New Brunswick and Nova Scotia.

Further Observations on the Eosin-Methylene Blue Agar

Simplicity in the differentiating of two types of bacteria often confused, Bact. coli and Bact. ærogenes, are claimed in the use of a medium brought forth by Max Levine, Associate Professor, Iowa State College, and further discussed in a paper presented by him before the Iowa Section of the American Water Works Association. These two organisms are encountered in water analysis in the confirmation of the presumptive test for Bact. Coli. As stated in his paper, the medium consists of 1.0 per cent peptone, 0.2 per cent dipotassium phosphate, 1.5 per cent agar, and 1.0 per cent lactose, with the dyes eosin and methylene blue as indicators. The medium has the advantage of extreme simplicity of preparation, as neither adjustment of reaction nor filtration are required.

The medium has been employed with success and satisfaction in the State Water Laboratories at Iowa City; in army laboratory schools for officers at Fort Leavenworth and Yale University; at the Army Medical School, Washington, D. C.; and at several large eastern water laboratories.

In the original report, read before the association in 1917, only one type of Bact. coli colony was described. Subsequent extensive observations have disclosed three distinct types of colony growth of this organism. The first, which we will regard the typical Bact. coli and which constitutes 95 to 98 per cent of the types encountered, has the following characteristics:

Isolated colonies are 2 to 3 mm. in diameter and they show very little tendency to run together. The colonies are slightly raised, the surface is flat or slightly concave, and the edge is even and regular when viewed with the naked eye. By transmitted light, they appear dark, and have almost black centers which extend more than three-quarters of the distance across the diameter of the colony. By reflected light they appear dark, button like, often concentrically ringed and show a distinct, characteristic, greenish, metallic sheen.

A second type of Bact. coli colony encountered resembles the typical form just described with respect to size and elevation, but there is no metallic sheen, the colonies being wine colored.

The third variety of colon colony appearing on this medium is somewhat larger (3 to 4 mm.) than the typical form described. It grows effusely or flat, the edge is crenated or irregular, and the central portion has a distinct metallic sheen. Several varieties of Bact. ærogenes have also been observed. The most frequently encountered colony type and the one which was originally described is as follows:

Well isolated colonies are larger than Bact. coli, usually 3 to 5 mm. in diameter, and neighboring colonies will quickly run together, forming a slimy, mucoid appearing mass. The colonies are moderately raised, markedly convex while the centers are a light to a dark brown, and relatively small (less than one-half the diameter of the colony). By reflected light, they appear much lighter than Bact. coli and there is no metallic sheen.

The second type of Bact. ærogenes encountered produces colonies somewhat larger than the one described above. The center is very dark, wine colored, and relatively large (often being more than three-quarters the diameter of the colony) and there is a glossy metallic sheen in young cultures. Confluence is very marked.

A third type of Bact. ærogenes observed is a small colony, often smaller than Bact. coli. The colonies are raised but the center drops precipitately like a crater. By reflected light, the small dark central portion may show a metallic sheen.

Whether these different types of colonies are of different sanitary significance has not as yet been determined, but it is apparent that the medium affords a means of differentiating varieties of Bact. ærogenes and Bact. coli which Mr. Levine believes has not been attained with any of the other media employed for confirming the presumptive test. It has also been observed that Bact. cloacæ and particularly Ps. pyocyaneus, which have occasionally been mistaken for Bact. coli on the standard Endo medium, grow very poorly on eosin-methylene blue agar, forming colonies which are not likely to be mistaken for either Bact. coli or Bact. aerogenes.

Test tubes may be substituted for petri dishes if desired. The value of such a change is, first, reduction of expense, as only 3 or 4 cc. of medium is needed for each test tube, while about 15 cc. is usually employed with a petri dish, and, second, test tubes may be stored for long periods; whereas the medium in petri dishes would have to be prepared at intervals of a week or less. The method of preparing test tubes is briefly as follows:

To 100 cc. of sterile melted phosphate agar is added 5 cc. of a 20 per cent lactose, 2 cc. of ½ per cent aqueous methylene blue solution and 2 cc. of a 2 per cent aqueous eosin. The medium is then poured aseptically into sterile test tubes and allowed to solidify so as to give a long slant without a butt. To confirm the presumptive test, inoculation is made on the surface of these slants with a straight platinum needle. If desired the medium may be placed in test tubes and sterilized in the Arnold or in the autoclave in the ordinary manner. In that case it will be found that the medium, when it comes out of the sterilizer, is fluorescent like eosin; but as it cools, the typical wine color returns.

The author has felt for some time that before much light will be thrown on the true relative incidence of Bact. coli and Bact. aerogenes in water, sewage, etc., it will be necessary to first modify our preliminary enrichment media or other conditions so as to enable an investigator to isolate or suppress Bact. coli or Bact. aerogenes at will.

Amounts of Unmetered Water Used for Street Cleaning at Rochester, N. Y.

Over 460 million gallons of water were supplied by the city of Rochester, N. Y., in 1919, for street flushing, street sprinkling, horse troughs and other public purposes, according to a paper by Stephen B. Story, Engineer Rochester Bureau of Municipal Research, which was presented at the last annual convention of the American Waterworks Association. The following table from his paper shows the quantities of water used for various public purposes. This water was not supplied through meters and the quantities were obtained by calculations based upon the best data obtainable. The total cost of this water at the wholesale rate was $46,000. The notes give in brief form the data from which the items of the table were computed.

UNMETERED WATER FOR PUBLIC USE, CITY OF ROCHESTER.

	Purpose.	Quantity.	Cost at 10 ct. per 1,000 gal.
A	Street flushing (by hand)	600,000	$ 60
B	Street flushing (by machine)	100,000,000	10,000
C	Street sweeping (by machine)	500,000	50
D	Street sprinkling	220,000,000	22,000
E	Sewer flushing (house laterals)	3,400,000	340
F	Sewer flushing (sewer laterals)	500,000	50
G	Sewer flushing (main sewers)	100,000	10
H	Snow removal flushing	3,000,000	300
I	Drinking fountains	1,000,000	100
J	Horse troughs	110,000,000	11,000
K	Parks and playgrounds	20,000,000	2,000
L	Exposition park	1,000,000	100
		460,100,000	$46,010

A. Street flushing (by hand). Measuremeents of water used for hand-flushing using 2½-in. hose, 1 in. smooth nozzle, hydrant pressure average 30 lb., are 1,000 gal. per 1,000 sq. yd. Figures for area flushed from Street and Sewer Bureau.

B. Street flushing (by machine). Six working days per week; 30 weeks per year. Tank capacity; flusher No. 1, 1,250 gal.; flusher No. 2, 1,500 gal.; flusher No. 3, 1,500 gal. Flusher No. 1, 29 fillings per day; flusher No. 2, 41 fillings per day; flusher No. 3, 44 fillings per day. Two additional flushers have been purchased of same type as flusher No. 3. Four wagon flushers with 60-gal. tanks, 56 fillings each per day. Add margin for waste in filling.

C. Street sweeping (by machine). Two Austin machine sweepers, 1,200 gal. per day, 200 working days. Double quantity required for working double shift as planned. Add margin for waste in filling.

D. Street sprinkling. Six days per week; 30 weeks in season. Forty tanks filled 40 times per day. Tank capacity. 750 gal. Allow margin for wastage in filling and temporary hydrant valves.

E. Sewer flushing (house laterals). 1,600 laterals flushed per year. Fifteen minutes per flushing is average time water is on. Hose and nozzle at 150 gal. per minute.

F. Sewer flushing (sewer laterals). One hundred sewer laterals flushed per year, 30 minutes per flushing is average time water is on. Hose and nozzle at 150 gal. per minute.

G. Sewer flushing (main sewers). Eleven sewers flushed per year. Sixty minutes per flushing is average time water is on. Hose and nozzle at 150 gal. per minute.

H Snow removal flushing. Varies yearly with amount of snowfall. Estimate 30 days flushing at 100,000 gal. per day.

I. Drinking fountains. Metered flow of fountain set up in meter shop was 25 gal. per hour. Run for five months per year. Twelve fountains of this type attached to fire hydrants around city.

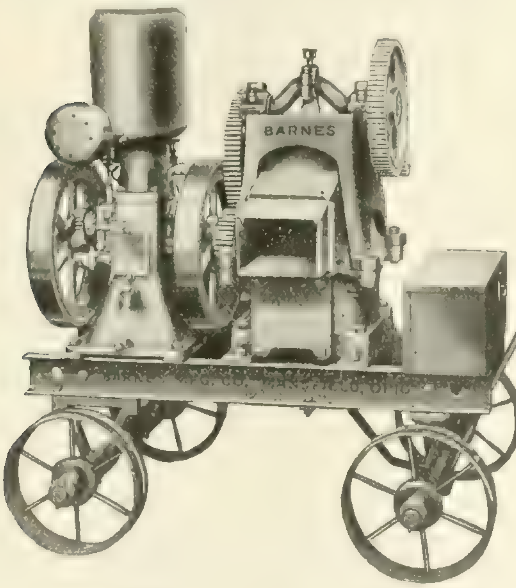
J. Horse troughs. Metered flow of one trough at 1,500,000 gal. per year. Seventy-five troughs operating all year in city.

K. Parks and playgrounds. Estimate based on consideration of playgrounds and parks being about half metered.

L. Exposition park. Estimate well within the actual use.

Two Pumps in One—A New Convertible Diaphragm Pump

A new convertible diaphragm pump has just been placed on the market by the Barnes Manufacturing Co., Mansfield, O. This pump can be quickly converted from the open spout "anti-splash" type to the closed spout "odofor" type—thus giving a pump for ordinary drainage work or one that will force the liquid above the pump, discharging through a hose or pipe instead of trough and handling sewage or the contents of catch basins in an odorless, sanitary manner. The new pump has many exclusive features. Its overhead jack construction eliminates a great many working parts, the forged steel crank shaft replacing about 15 or 20 parts in the old walking beam construction. In addition to having fewer parts this overhead jack construction is stated to be much stronger and will give longer life on account of its long bearings and heavy working parts. The diaphragm is held in place by a clamping ring which is separate from the jack so that the latter does not have to be disturbed when the diaphragm is replaced. The suction valve is especially noteworthy. It may be removed for inspection or repairs without disturbing the suction hose. This is a very important point since it is often difficult to replace a hose so as to have all jonts air tight. This valve is more efficient and has longer life than the old rubber flap valve. In addition it may be faced with any kind of sheet rubber, leather or canvas and does not require high grade material which is hard for the contractor to obtain. The pump is adapted to handling all kinds of drainage work such as pumping out trenches and excavations of all kinds. It is stated to have a capacity of 10,000 to 12,000 gal. per hour.



Barnes Convertible Diaphragm Pump.

Personals

[illegible]

Gelasio Caetani, a graduate of the School of Mines of Columbia University and a mining engineer of note, has been elected Mayor of Rome, Italy. For a number of years he was connected with mines in the western states.

Dr. Weir H. Miley, a local physician of Anderson, Ind., has been appointed city sanitarian by the Anderson Board of Public Works. He will succeed W. C. Roush, city chemist, who was in charge of the city water filtration plant.

Dorsey W. Hyde, Jr., has left the Transportation Engineering Division of the Packard Motor Car Co. to become assistant manager of the recently-created Civic Development Department of the Chamber of Commerce of the United States, Mills Bldg., Washington, D. C., of which John Ihlder is manager.

George W. Cutting, Jr., recently engineer, production department of the Atlantic Corporation, constructors of steel cargo ships at Portsmouth, N. H., has resumed practice at 10 Post Office Square, Boston, Mass., where he will engage in property development, landscape engineering, drainage, sewerage, road location, surveys, investigations and reports, superintendence of construction, etc.

The Fargo Engineering Co., of Jackson, Mich., has filed articles of incorporation with a capital stock of $50,000, all paid in. The officers are Wm. G. Fargo, president, Horace S. Hunt, vice-president, Rolla G. England, secretary-treasurer. This company is a consulting engineer firm which has been active in water power, steam power and general industrial work in the middle west for 20 years. It is the outgrowth of an engineering office opened by Wm. G. Fargo in 1890 in Jackson. Of Mr. Fargo's associates Mr. England has been with the organization since 1899, Mr. Hunt since 1905 and Mr. Streiff since 1910.

Holbrook, Warren & Andrew, of Decatur, Ill., have purchased the business of Miller, Holbrook, Warren & Co., Decatur. Under the latter name, the firm has built up a substantial professional business in the structural and municipal fields. Mr. Frank D. Holbrook was engaged for a period of about 15 years on Ohio river improvements for the U. S. Government. Mr. Willis D. P. Warren has been engaged in various classes of engineering work in Illinois for the past 17 years, devoting the greater portion of this time to municipal projects. Captain Clarence R. Andrew was formerly with the Government on Ohio river improvements and served in France in the Engineer Corps.

Dr. F. G. Cottrell has resigned as director of the United States Bureau of Mines. He leaves the bureau to take up his duties as chairman of the Division of Chemistry and Chemical Technology of the National Research Council. H. Foster Bain, of California, succeeds Dr. Cottrell. Mr. Bain was educated and trained as a geologist and mining engineer. He was one of Herbert Hoover's assistants in London on the Belgian relief work during the war. Before that he was editor of the Mining and Scientific Press of San Francisco, Calif., and later the editor of the Mining Magazine of London, England. He made some important mining investigations in south and central Africa and later undertook similar investigations in China. At one time he was a mine operator in Colorado and once was connected with the United States Geological Survey. Subsequently, he was the first director of the Geological Survey of Illinois.

Obituaries

Charles B. Hogle, for many years superintendent of construction for the Scioto Valley R. R., died Jan. 3 at his home in Columbus, O. He was 78 years old.

Paul Ludwig Wolfel, an engineer of the McClintic-Marshall Co., died Dec. 27 in Philadelphia, aged 58 years. He formerly was an engineer for the American Bridge Co.

Michael H. Foley, a railroad contractor, died recently at his home in Los Angeles. He was the last of the four Foley brothers of St. Paul, who were pioneer railroad builders. These were himself, Thomas, John and Timothy. Timothy died only recently.

James Herring, civil engineer for George H. Hardner, contractor, Allentown, Pa., died Dec. 29, aged 47. Mr. Herring was a graduate of Union College and for a time was employed by the firm of Schofield & Co., Philadelphia engineers and contractors. Twelve years ago he was engaged by Mr. Hardner to take charge of the engineering work of his firm and in that time was engaged in some large operations.

Industrial Notes

The Strauss Bascule Bridge Co., has moved its home offices to 225 North Michigan Ave., Chicago.

R. B. Murdock has resigned as executive engineer of the Asphalt Association and now represents The F. D. Cummer & Son. Co., of Cleveland and New York, manufacturers of asphalt paving plants and dryers. Mr. Murdock has offices at 19 West 44th St., New York City, and is concerned with eastern domestic and export sales.

H. H. Robertson Co., of Pittsburgh, manufacturers of Robertson Process Metal, announces the appointment of Benton Hopkins as branch manager with offices in the Kirby Bldg., Cleveland, O.; also the resignation of Arthur B. Shepard, for 12 years district manager of the Cleveland office, who resigns to take up the active management of the Arthur B. Shepard Co., manufacturers of standardized structural steel buildings.

The Austin Machinery Corporation, of Chicago and New York, manufacturers of earth-working, concrete-mixing and material-handling machinery, has acquired the plant of the Fairmont Machine Co., of Fairmont, W. Va. The Fairmont plant will continue to make its own line of machinery besides contributing to the manufacture and distribution of the line of earth-handling and cement-mixing machinery manufactured by the Austin Machinery Corporation.

The Chicago Pneumatic Tool Co. announces the appointment, Jan. 1, 1921, of R. F. Eissler, as assistant to the vice president with headquarters in the company's new office building at 6 East 44th St., New York. W. C. Straub, formerly district manager of the New Orleans branch, has been appointed district manager of the Pittsburgh branch to succeed Mr. Eissler, and Ross Wyeth, formerly attached to the Pittsburgh branch, has been appointed district manager of the New Orleans branch to succeed Mr. Straub.

The T. L. Smith Co., whose general sales offices have been located at 470 Old Colony Bldg., Chicago, has moved this entire department and its complete personnel to Milwaukee, Wis., where it will be located from now on, at the factories, 1125 32nd St. The advertising department will also operate from the factory from now on . This move was made principally to accomplish closer co-ordination between sales and service. General Sales Manager R. E. S. Geare will now have direct jurisdiction over the service department at the factory.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The Battle Between "Original Cost" and "Present Value" of Railways and Utilities

A majority of the National Association of Railroad and Utility Commissioners at its recent annual convention declared in favor of the actual "honest and prudent investment" in a utility as the rate-making "value." Almost coincidently Judge Van Valkenburgh in the Federal Court at Kansas City held "that the great weight of authority is against the original cost as a controlling basis for determining present value," and he granted an injunction restraining the Public Service Commission of Missouri from enforcing an order fixing street railway fares based on an original cost valuation. Judge Van Valkenburgh follows the decisions of the U. S. Supreme Court, and we doubt not that his decision will be sustained.

The following is the resolution that was submitted to the Association of Commissioners:

Whereas in recent years the cost-of-reproduction method of evaluation has in many instances become the controlling factor in determining the fair value of the property of public utilities, and

Whereas during the past few years there has been an unprecedented increase in the cost of materials and supplies entering into the construction of utility properties, and

Whereas, the cost-of-reproduction method of evaluation, although applied with moderating averages, arbitrarily attaches to properties constructed before the high-price period, values greatly in excess of the actual prudent investment therein, in many instances from 25 to 100 per cent greater than such investment, and

Whereas under present abnormal conditions the cost-of-reproduction theory has ceased to perform the service which it was designed to perform, and now leads to the unwarranted and unreasonable values which offer little guidance in determining the fair value of the property of public utilities, and

Whereas the continuance of the cost-of-reproduction theory as the controlling factor in public utility valuations will in the future undoubtedly cast a burden upon those utilities which were required by public necessity to make substantial plant investments during the high-price period; now, therefore, be it

Resolved, by the National Association of Railway and Utilities Commissioners, that a continued disposition on the part of commissions and courts to consider cost-of-reproduction or cost-of-reproduction-less-depreciation as the controlling factor in determining the value of the property of utilities will tend to impair scientific and equitable regulation, to permit the establishment of unwarranted and unreasonable values, and ultimately to diminish public confidence in commissions and courts and thereby impair their usefulness; and be it further

Resolved, that one of the obligations of commissions and regulatory bodies is to protect and preserve, in so far as it lies within their power, honest and prudent investment in utility properties, and that, in view of abnormal price conditions now prevailing, equity, justice and a proper regard for the interests of utilities as well as the public seem to demand that in the valuation of public utility property greater weight should be given to the honest and prudent investment therein; and be it further

Resolved, that it is not intended by this resolution to hold that the fair value rule should be abandoned or impaired, but rather that under the fair value rule and in view of abnormal conditions prevailing, a greater measure of justice and equity will be secured by giving greater weight to honest and prudent investment, and less weight to the cost-of-reproduction or cost-of-reproduction-less-depreciation.

Twenty-one states favored the resolution, eleven were noncommittal, and only two opposed it. The reasoning involved in this resolution is, we believe, faulty. It amounts first to asserting that the duty of a state is to protect investments in public utilities, and then to inferring that the protection should consist in requiring the investor to accept depreciated dollars. This is the sort of "protection" that really protects no one but the patrons of a utility, for they are allowed to pay in "Mexican dollars" for the use of an investment that was made in "American dollars."

This aspect of the case appears as yet to have had little weight with utility commissions, but we predict that their sense of fairness will ultimately lead them to see that when the buying power of a dollar is halved, a stockholder is quite as much entitled to have his money income doubled as is a wage earner.

The idea of protecting investors in public utilities is, of course, sound; but the fallacy in the reasoning of many utility commissioners occurs when they fail to see that real protection is given only when the real income (as distinguished from the money income) is kept intact. Men do not invest their capital to secure money, but to secure the commodities and services that money will buy. These are the real income from investments, and these should not be taken from an investor under guise of protecting him.

Against this argument it is sometimes urged that many investors in property that is not subject to state regulation would be delighted to be assured a constant real income. The fact is, however, that the vast majority of investors prefer to put their capital in property that is free to earn as much as good management and good luck will permit; and it is only when hard times come that they ever talk of being satisfied with the small dividend rates that the average public utility company is permitted to declare.

The resolution under discussion speaks of the "abnormal price conditions now prevailing" as an argument in favor of actual investment as the rate-making base. But who can define what a "normal price" is? And, having defined it, who can foretell when it will prevail? Or how long it will last? The fact is that there is no meaning to the expression "normal price" except as used to designate an "average price" over a term of years. But how is the term of years to be determined? Shall it be 5, 10, 20 or 50 years? Any one who has studied the causes that affect price levels knows that prices do not oscillate about a mean, but move in waves of the utmost irregularity. There is, therefore, no standard price level that is other than a purely arbitrary standard.

It is sometimes contended that an investment made at the present price level will shrink in value in a few years, and that protection is given to the investor when he is assured that he will be allowed to earn, say, 8 per cent thereon after the shrinkage in prices has occurred. But such protection would be unfair to the public, for it would amount to giving the investor an unearned increment in his real income, because of the increment in the buying power of a dollar.

If the public and the investors in public utility stock are to be equally protected by commissions and courts it must be done by studying their respective real incomes, and not by considering merely their money incomes.

Let Us Stop Industrial Crucifixions

The most important recent improvement in street car operation has been the introduction of the one-man car. Like almost every other labor-saving device that has dispensed with the service of many men at one stroke, it has been opposed by labor unions. As an example of this opposition we quote the following:

> William J. Murphy and other members of the joint conference board representing the employees of the Bay State system, have applied to the State Supreme Court for an injunction to restrain the company from operating cars of this type. The Bay State management has announced that it will discharge all men detected in the act of spreading propaganda against the one-man cars.
>
> The operation of rebuilt double-truck cars by one man has for some time been a disputed question between the management of the Eastern Massachusetts system and its employees. The men have contended that the use of such cars endangers both the car operators and the public. They also strongly object to the introduction of the one-man cars on the ground that many of their [illegible] are thus deprived of work. A majority of the cars now [illegible] equipped to be operated by one man.

The Massachusetts Department of Public Utilities has ruled that the double-truck, one-man cars are not a "menace to public safety," for it was patent that such a charge was merely camouflage for the real objection to the use of one-man cars.

So long as labor unions oppose labor saving devices, they will meet with scant sympathy from the public. Nevertheless workmen who lose their jobs because of the introduction of better machines are entitled to sympathy, and they would undoubtedly receive it were they to take reasonable action to protect themselves from idleness. Just what action they should take may be difficult to determine. Perhaps they should ask the public to support them until they secure another job. Perhaps they should insist upon being taught a new trade at public expense. It seems no more than right that the public should assume the burdens that accompany economic progress, for it is the public that reaps nearly all of the benefits.

The public, however, is an indifferent and often a cruel master. It says to the trolley conductor who has lost a job because of the introduction of one-man cars: "We admit that we benefit at your expense, but there are many jobs to be found in the world. Go hunt a new one."

To the public it matters not that the man thus thrown out of employment may know no other trade, or that he may have partly paid for his home and will lose all if he moves to another town. Against this injustice the discharged workman rebels, and who would not? In his anger he seeks any weapon of defense. He even tries to block the wheels of progress. It is idle to tell him that to labor saving machinery the American owes most of his economic superiority over the Chinaman. This he will grant, but still he will ask why he should be the one to be nailed to the industrial cross.

The solution of this great economic problem—for such it is—will not come by preaching from the text of human progress, but by devising practical means of making the public bear the burdens that are now loaded upon the individuals who lose their jobs because of economic changes.

Book Review

"Contracts in Engineering," by James Irwin Tucker, B. S., L. L. B., Director of the School of Civil Engineering, University of Oklahoma; second edition, 331 pp. McGraw-Hill Book Co., New York; $4.00.

This second edition of an already well known book should have a ready welcome by engineers, contractors and business men, although primarily written for students in engineering colleges. The special aim of this book, as stated by the author, is to state and make clear the guiding principles underlying the interpretation and writing of engineering-commercial agreements.

In the introduction the author has very clearly justified his reason for writing the book and has emphasized the need for engineers becoming better acquainted with the laws of business.

The chapter headings are: Business of Contracting; Contract Essentials; Development of Contract Principles; Agency, Fort, and Independent Contractor; Real Property; Contracts of Association—Corporations; Contracts of Sale and Transportation; Negotiable Paper; Preparing and Writing Engineering Contracts; Appendix Notes.

Special features of the book are the sets of questions at the end of each chapter, which are designed to illustrate the principle stated in the text; and the analytical diagram of each chapter, which in the space of a page, gives a bird's-eye view of the chapter's contents.

Cost of Motor Bus Operation at Winnipeg.—The motor bus service operated by the Winnipeg Electric Ry. Co., Winnipeg, Man., cost 25.7 ct. per mile for the 7 months ending July 31, 1920, according to the December issue of Aera. The company operates seven 16-passenger buses on routes which serve as feeders to the railway. Only five buses are in regular operation, the others being held in reserve for emergencies. The cost of the five buses was $12,930, and the total miles operated during the above period was 66,183. The cost of operation for the 7 months, according to a statement of the company, was as follows:

		Total costs.	Cost per mile, ct.
Drivers		$ 5,366.30	8.12
Tires		980.84	1.48
Gasoline		3,593.14	5.42
Oil		328.90	.48
Labor for repairs		2,056.42	3.11
Materials for repairs		1,072.91	1.62
Storage rental		350.00	.53
Insurance:			
Liability	$630.00		
Fire	52.78		
		682.78	1.06
Taxes, including drivers' licenses:			
Provincial and city car licenses		152.00	.23
General expenses, including supervision, accounting and other overhead expenses		312.93	.47
Total of above expenses		$14,896.22	22.52
Depreciation		1,508.50	2.28
Interest on investment		603.40	.91
Total costs		$17,008.12	25.71

°Gasoline in Winnipeg cost 37 ct. per gallon in January last, 47 ct. last June and in October 51 ct.

Ignorance of Science

In these days when the colleges are being criticised from various points of view and many innovations are being introduced into education, anything that throws light upon the subject should be welcome. One of the most illuminating criticisms of the failings of education is contained in H. G. Wells' recently published "Outline of History." Mr. Wells, as is well known, received a scientific education and believes, as Huxley did before him, in the need for leavening the old-time classical studies with a considerable proportion of well-taught physical science.

It is in his account of Mr. Gladstone that Mr. Wells assails the old pedantic education that, in spite of its virtues, has so hampered our colleges. Mr. Wells explains the old-time classical training as consisting mainly of "the study, without any archæology or historical perspective, of the more rhetorical and 'poetic' of the Latin and Greek classics." The graduates from such a course, continues Mr. Wells, had no vision of history as a whole, were ignorant of the elementary ideas of biological science, of modern political, social and economic science and modern thought and literature. Such an education as Mr. Gladstone's is typical of that of many of our public men, lawyers and even some business men. Mr. Wells' test of an education is whether it enables one to interpret correctly the life around him; of Mr. Gladstone he says that he never attained any real vision of the world in which he lived.

For instance, "When Mr. Gladstone was taken by Sir John Lubbock to see Charles Darwin, he talked all the time of Bulgarian politics, and was evidently quite unaware of the real importance of the man he was visiting. Darwin, Lord Morley records, expressed himself deeply sensible of the honor done him by the visit of 'such a great man,' but he offered no comments on the Bulgarian discourse." Obviously this Eton and Oxford graduate, intellectual as he was supposed to be, had little conception of the world-moving importance of Darwin's work in science. Therefore, reasons Mr. Wells, since he could not interpret correctly the life around him, he was not educated.

Again, Mr. Gladstone paid a visit to Faraday, "the English electrician, whose work lives wherever a dynamo spins, who is in the airplane, the deep-sea cable, the lights that light the ways of the world, and wherever electricity serve our kind. . . . The man of science tried in vain to explain some simple piece of apparatus to this fine flower of the parliamentary world. 'But,' said Mr. Gladstone, 'after all, what good is it?' 'Why, sir,' said Faraday, doing his best to bring things home to him, 'presently you will be able to tax it.' " If Mr. Gladstone could see the great power-houses and electric lines today, all of which have come from Faraday's humble experiments of a century ago, he would see "what good it is"; and he might see also how poorly his education in what Mr. Wells calls rhetorical literature fitted him to understand the progress of his time.

But Mr. Gladstone is not the only prominent man who has failed to do justice to science because of a narrow education. Our own Congress hesitated six years over voting $30,000 to test Morse's telegraph, even after he had demonstrated its merits. When the appropriation was being discussed, one Congressman proposed an amendment that half the money be given for an investigation of mesmerism. When the vote was taken on the original motion (the amendment having been defeated), it carried by only 89 to 83. Morse meanwhile had nearly starved to death, after vainly trying to get European nations to buy his invention.

Coming down to the present, it is not difficult to see similar blindness to the importance of science by men trained to the old classical standards. Congress still votes huge appropriations for more or less useless projects, while cutting to the minimum any sums devoted to engineering or to scientific research. When, occasionally, large amounts are voted for necessary engineering undertakings, men untrained in science are as likely as not to be put in charge. Engineers and technologists employed by the national, state and municipal governments are given as little authority as possible, and are paid salaries astonishingly small compared with what Government-employed lawyers and publicists are paid.

One of the most striking examples of lack of knowledge of science is in our newspapers and general magazines. Reporters with almost no understanding of science are assigned to write accounts of scientific importance, and the way in which they garble the facts and falsehoods they pick up is a disgrace. The apportionment of space in the newspapers further emphasizes the prevailing ignorance of science among men who have received the traditional arts education. Half a page is devoted to a murder or a scandal, or even to a wedding or a society rumor, whereas a tiny paragraph in the lower corner has to do for an important scientific discovery.

It is interesting to observe how ignorant people in general are when a scientific matter is mentioned. Speak in the ordinary club or at a general social gathering some such term as "organic acid" or "fuselage" or "metallurgy," and notice the blank looks that follow. As Herbert Spencer pointed out, the customary education that most people receive makes them more anxious to pronounce correctly some word of merely literary significance, such as "Iphigenia" or "Don Quixote" or "L'Allegro," than to understand the scientific phenomena among which they live. Listen to the remarks of the average citizen as a street car passes a bridge under course of construction, or when the composition of the latest anarchist bomb is discussed. In spite of all the books on science available, and all the science courses in our schools and collegs, the average citizen, like the lawyer and the reporter and the public man, is astonishingly ignorant of science and engineering.—Editorial in Chemical and Metallurgical Engineering.

Labor Assumes a New and Constructive Attitude

Taking the statements of Matthew Woll, vice-president of the American Federation of Labor, as representing the attitude of organized labor which has crystallized out of the past few years of unprecedented unrest, it appears that the efforts of the engineers on the particular problem (relations of capital and labor), mentioned above, as a part of the program of American Engineering Council, will be most welcome to the workers of the nation. Mr. Woll indicates that labor is now ready to co-operate in any and every way to increase production and he commends specially the work of efficiency engineers and others who have been trying through scientific analysis to make each man's efforts count for more. This appears to be a change in attitude which is wholesome and from which there should be untold benefit to the entire community. It is an attitude, of course, which is nothing more nor less than should be expected from a disinterested consideration of how each man may make the most of his opportunities in whatever capacity he finds himself, but, frankly, this has not been the apparent attitude of organized labor on this subject in the past. Mr. Woll has been accused of being an opportunist, but this stand, we hold, is so patently clear and logical that to uphold it can serve no temporary purpose, but must result, if maintained with any self-respect, in real advancement.

Engineers should be particularly pleased to find that their work of years is commencing to bring fruit in a most gratifying manner. Mr. Hoover, as the newly elected president of the American Engineering Council, mentioned this subject the day after Mr. Woll's declaration, and immediately recognized the added opportunity thus thrown open to the engineers in their efforts to work for better economic and social conditions in this country.

Electric railways have always had certain difficulties in this line and have faced labor problems more complex than in most other industries. If the engineer, the scientific analyst, can be accepted by both labor and capital as the proper person to undertake the task, he can be of service which will prove invaluable to railway properties in working toward more efficient operation, in providing better service to the community and in improving the general relations between capital and labor.

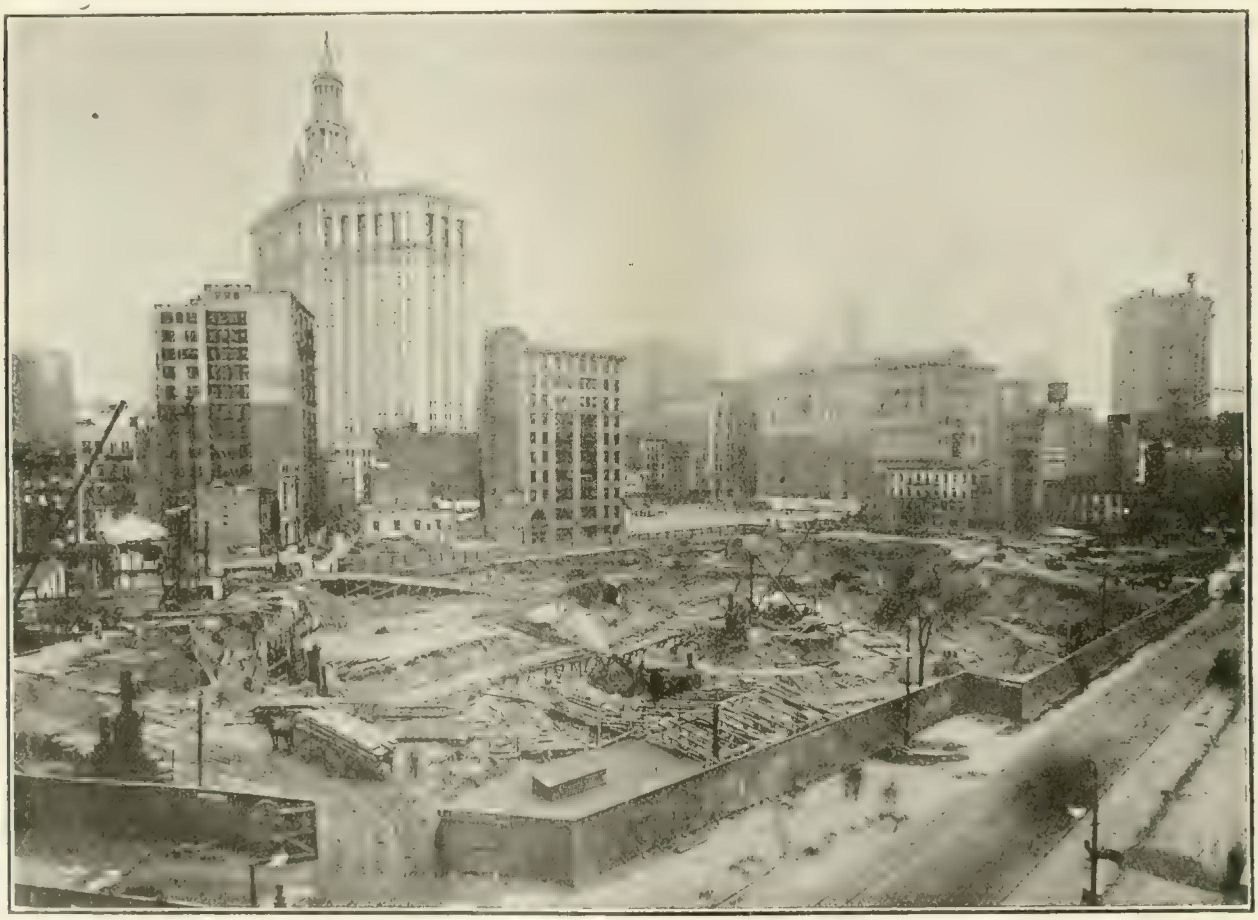
It may be, as the New York Times says editorially, that Mr. Hoover may "bring Mr. Gompers to accept engineers as a golden bridge between labor and capital."—Editorial in Electric Railway Journal.

35,132 Students at Engineering Schools in 1920.—Statistics collected by the Institute of Public Service, New York City, show that in 1920, 65 engineering colleges in this country had a total of 35,132 students. In 1917 these colleges had 22,695 students and in 1914 21,419

Methods and Plant for Excavation for Substructure of New York County Court House

The new $20,000,000 Court house for the County of New York is located on Center St., New York City, a few hundred feet from the great municipal building. The buildings formerly occupying this site were taken down several years ago. During the intervening period between that time and the present a quantity of ashes were dumped into the open cellars resulting from the razing of the old buildings. During the war the United States government used this area as a naval encampment.

The excavation under this contract therefore consisted of several classes: Miscellaneous for a depth of about 10 ft.; masonry foundations amounting to several thousand cubic yards; and an underlying stratum of well-graded sand below the old cellar levels.



General Excavation Nearly Completed. Concrete Plant Installation Commenced at Left and in Center. Ramp for Trucks is Shown in Background.

Due to water being reached at elevation + 2.0, a great deal of pumping has been required to successfully carry the excavation down to elevation — 11.75, the sub-grade of the foundation rings of the new court house. The quantity pumped has averaged about 3,500,000 gal. per 24 hours.

The entire excavation is approximately about 500 ft. long, 320 ft. wide and about 30 ft. deep, and required the removal of 94,000 cu. yd. of material.

The masonry included in this contract consists of foundation rings, the sub-basement floor and the exterior walls extending up to street grade. The concrete amounts to about 19,000 cu. yd., which was mixed and placed entirely with power plant. This work will be described in our Jan. 26 issue. The contract for the sub-structure was awarded Aug. 15, 1920, to Rodgers & Hagerty, Inc., New York City, for about $2,000,000.

Excavation was done entirely by steam shovels, two of which were immediately installed, and the others following as soon as was practicable. Three of them were of the revolving type with 1-yd. buckets. They were manufactured by the Bucyrus, Marion, Osgood and Thew companies.

The first shovel made a full-length cut across the width of the lot, traveling west on the east and west center line. The cut was about 30 ft. wide and 10 ft. deep, and at the farther end the shovel turned and came back to the starting point, widening the cut as it advanced. As soon as possible the other steam shovels were installed in the cut at the same level, working out from the center to the edges of the excavation, which, in general, were allowed to take a natural slope within the limits of the excavation.

While three shovels were thus employed in completing the first lift, the other shovel made a full-length through cut on the second lift, where it was followed by the other shovels, which excavated in the same manner as for the first lift, and all proceeded to the third lift, completing the main excavation down to elevation — 8.0, about 26 ft. below the surface of the street and 10 ft. below ground-water level.

The shovels delivered directly into a fleet of forty-five 5-yd. elevating automobile dump trucks that followed each other, closely forming a continuous line passing the shovel, receiving the load and giving way to the next truck, so as to keep the shovels busy with very little loss of time.

When operations were commenced a ramp of solid earth was left at the east end of the pit for the entrance and exit of the trucks, and a hoisting engine was installed at the top of the ramp to haul out the loaded trucks. When the second lift of the excavation was commenced, there was constructed on the south side of the pit another ramp with wooden flooring and falsework trestle bents, which was maintained for trucking spoil from the second and third lifts of the excavation and from subsequent pits, and permitted the removal of the earth in the first ramp. Although the sand from the upper part of the excavation was coarse and sharp and well-suited for concrete, it was not accepted for this purpose and was all hauled about 1½ miles and dumped into scows at piers on both East and Hudson rivers.

Although there was considerable clearance between the bottom of the excavation and the margin of the street, enough generally to provide a 1 on ½ slope of material as it was left by the steam shovel, it was thought best to run no risk of caving in of the bank or undermining or settlements in the streets, and the sides of the pit were protected by a sheeting of Lackawanna steel sheet piles 20 to 22 ft. long, driven midway of the slope at about the bottom of the first lift, to a penetration of 2 or 3 ft. below sub-grade. These formed in all a total of about 900 lin. ft. of retaining wall and were driven at the rate of about 20 sheet piles per day by a McKiernan-Terry steam hammer. The piles were driven before the final lift was excavated.

The large amount of ground water encountered necessitated vigorous pumping after commencement of excavation in the second lift. Accordingly an 18x18-ft. sump lined with wooden sheet piles, and excavated by a 1-yd. clam-shell bucket operated by a derrick boom, was driven down to about 3 ft. below sub-grade and over it there was built a shelter in which were installed two Kingsford centrifugal pumps, 10-in. suction, one Kingsford centrifugal 8-in. suction, one Lawrence centrifugal 6-in. suction, one Lawrence centrifugal 4-in. suction, and two 10-in. Cameron steam pumps, all centrifugal pumps being electrically driven.

From the sump six shallow radial trenches 50 to 150 ft. long were dug and in them were installed sections of spiral riveted 18-in. pipe which received the drainage from the lateral ditches reaching to all parts of the excavation and closely following the steam shovels, in which were laid ordinary tile drains. This system was easily shifted as the work advanced and kept the ground dry enough to support the steam shovels without difficulty. When the excavation had been completed to sub-grade a similar system of drains was permanently installed below the level of the footings and the ends of the drains were closed and covered by stone and gravel which freely admitted the water and prevented the accumulation of earth and sand that might stop them up. The drains were thus kept open so that the water was continually taken care of by the regular pumping that at the present time averages about 3,000,000 gal. in 24 hours and has been in the earlier part of the work over 4,000,000 gal. in 24 hours. Such water is usually handled by the centrifugal pumps alone, keeping the two steam pumps in reserve in case of emergency.

General excavation was carried down to grade elevation —8.0, about 26 ft. below the surface of the street and about 3½ ft. above the bottom of the foundation footings. This left about 3,000 yd. of excavation still to be made for the footings, providing a quantity of fine sand about sufficient to backfill between the upper part of the footings up to the level of the bottom of the sub-basement floor. Consequently after the completion of the general excavation, two of the steam shovels, a Thew and an Osgood, were left in the pit to handle the footing excavation, which was made simultaneously with the placing of the concrete below the sub-basement floor and was arranged as much as possible so that the shovels could in some instances excavate the footing trenches and pass the material back for backfill at the same motion of the dipper, thus eliminating rehandling of materials. In other cases the spoil from the footing excavation was piled in ridges or winrows parallel to the footing trenches, and afterwards back-filled by the steam shovel after the completion of the concrete footing, thus in both cases eliminating the necessity of hauling the material or rehandling it with derricks and buckets.

The Chicago Good Roads Convention.—Among the subjects to be considered at the congress of the American Road Builders' Association, at the Coliseum, Chicago, Feb. 9-12, are the following: "Our National Road Problems," "The Relation of the Highway and Motor Transport Movement to Education," "Highway Improvement in New England," "Highway Transportation," "Types of Pavements," "The Local and National Importance of the Lee Highway," "Subgrades," "Recent Developments in Road Building," "Highway Finance," "Relation between Highway Engineers and Contractors." All sessions of the Congress will be held in the convention hall of the Coliseum, one flight above the exposition floor, where the exhibits of road building machinery, materials and methods will be located. The congress and the exposition will be open at all times to those interested in highway improvement.

A Study of the Costs of Grading with Elevating Grader and Wagons

An interesting discussion of the cost of grading with an elevating grader and wagons was given by the committee on "Education as to Costs" of the Northwestern Association of General Contractors, in a preliminary report submitted to the association. The committee consists of J. C. Baxter, chairman; Day Okes, A. C. Dixon, Peter Nelson and E. A. Studer. The report, which is based on an analysis of the costs of an ideal grading job done under ideal conditions, follows, the text being reprinted from the December Bulletin of the Associated General Contractors of America:

In order to establish a basis from which to make this study, we have first written specifications for a piece of grading work which, we believe, describes work that for excellence and desirability is never actually encountered in the field. The thought being that our membership, after reading this specification and examining our study of the cost of doing the work described will, if they approve of the cost submitted make such additions thereto when considering actual work on the ground as in their judgment are required to make the estimated cost of the work examined on the ground sufficiently great to cover the differences which, in their judgment, exist between the actual work under consideration and the ideal piece of work that we have described.

Steam Shovel Back-filling Around Concrete Foundations.

Specifications for the Ideal Elevating Grader Job.

The ideal elevating grader job shall consist of the excavation by elevating grader and the haul by 2-horse wagons of 70,000 cu. yd. of material during the months of June, July, August, September and October.

The length of the work must not exceed three miles and the natural surface of the ground shall not exceed a 10 per cent grade longitudinally, nor an 8 per cent grade transversely. The average haul on all material shall not exceed 800 ft., and the rate of grade on the finished work shall not exceed 2½ per cent. The ditches shown on the standard cross section for finished cuts shall not exceed 8 ft. in width on top, nor 2 ft. in depth.

The material to be excavated must be such that a No. 5 railroad plow can be easily drawn by two 1,400-lb. horses; it must be free from boulders and of such structure as to elevate easily and pack firmly for wagon tracks. The cuts must be dry and free from stumps and roots, and the area on which embankments are to be constructed must be free from swamps and stumps.

The work must not be interfered with by traffic or old wagon roads, and water for horses and camps and camp sites must be available within 500 ft of the center line near the middle of the work.

The middle of the work must not be greater than three miles from a railroad station.

Estimate of Cost of Ideal Job.

Outfit. As the first step in making an estimate of the cost of performing the work described by the specifications for the ideal elevating grader job, it will be necessary to determine the cost of an outfit suitable for carrying on such a piece of work, and we append hereto Schedule "A," which is a detailed estimate of the present cost of an elevating grader outfit the total of this estimate amounting to $22,818.05, which for discussion in this report we will call $23,000.

Depreciation.—Having ascertained the cost of an outfit for carrying on the work under discussion, we must now arrive at an annual charge to cover depreciation and obsolescence, and this charge must be sufficient to maintain the contractor's investment in the outfit at its original figure.

The committee has had the privilege of hearing several owners of team outfits express their opinions on this subject, and has discussed the matter with them, and we believe 20 per cent per annum to be a proper charge to make on the new value of a team outfit to cover depreciation and obsolescence; or, in this case, 20 per cent of $23,000, or $4,600 per annum.

Interest.—The amount of money invested in an outfit is not a measure of the total capital required to carry out a grading contract, as the contractor must have available funds for moving on to the work and for carrying on the work till such time as monthly estimates are payable.

The committee believes that for the piece of work under consideration the contractor should have, in addition to outfit, available financial resources amounting to $10,000, and it is obvious that when we compute the interest chargeable to the work it must be calculated on the cost of the plant plus the amount of ready money the contractor is required to keep on hand. In this case, on $23,000 plus $10,000, or $33,000, interest on which for one year at 6 per cent amounts to $1,960.

Supervision.—We must now discuss the earnings of the contractor himself, and we will assume that an outfit such as we are discussing is owned by one man, and that where two or more individuals form a contracting firm a proportionately greater outfit will be owned and operated.

The contractor has his money tied up in the outfit and ready cash, and the interest on this amount could be obtained in any one of numerous investments while the man himself was employed in some work for which he was paid a salary. Consequently, he must receive a reasonable salary as part of the cost of the work before any profit can be made, and we believe $2,500 per annum to be the minimum amount that should be charged to the work to cover the salary of the contractor.

Taxes.—Taxes are another item that must be charged to the work, and we believe that $150 per annum is sufficient to pay the taxes assessed on a team outfit.

General Expenses.—General expenses incurred by the operation of one elevating grader outfit seem to vary greatly, but from information we received we believe that $1,500 per annum is the minimum which should be charged to the work to cover office, telephone, traveling expense, storage, etc.

Winter Expenses.—Winter expenses of a team outfit are a relatively large item, and our estimate of the cost of them is made from data furnished by team outfit owners.

Under the terms of the specifications for the ideal elevating grader job, the grading outfit is to work five months, and consequently it will be idle seven. It is assumed that of these seven months the horses can be rented in the woods for 3½ months and will be idle for 3½ months. On this basis the cost of winter expenses would be as follows:

[illegible]

[illegible] contractor's bond [illegible] under consideration will approximate $600.

Freight.—The cost of freight to and from the work based on the amounts actually paid during this past year will be about $1,000, and that figure will be used in our estimate.

Moving.—The cost of moving on to the work from the contractor's yard, setting up camps, and upon completion of the work moving back to the contractor's yard, we estimate 8 days at $100 per day; total, $800.

Camp Site.—Figures submitted to us indicate that $150 is about the average cost of camp site rental, and that figure will be used in our estimate.

Cook House.—Under present conditions when charging the wages of cook and flunky to labor expense, and assuming board to be figured at $40 per month per man, a team outfit will probably lose $100 per month on the cook house.

Automobile.—Ford automobiles have largely taken the place of driving horses in team outfits, and we have included the cost of a Ford machine in our estimate of the cost of outfit. This machine will cost about $50 per month for operating expenses.

Running Repairs.—From various information furnished us by the owners of team outfits, it appears that $200 per month is a fair average of the cost of running repairs.

Labor.—Estimated cost of labor for operating elevating grader outfit for one month. Rates include board assumed at $40 per month per man:

1 Foreman	$ 265
1 Timekeeper	140
1 Cook	150
1 Flunky	115
1 Blacksmith	200
1 Barn man	140
1 Machine driver	200
1 Plow man	240
1 Push car driver	140
1 Gig driver	140
1 Dump man	190
1 Laborer	125
11 Teamsters at $125	1,375
23 Men. Total	$3,420

Horse Feed.—Estimated cost of feeding horses for elevating grader outfit for one month:

The committe makes the following assumption as to cost of feed and amount required per horse per day:

Oats, per bushel	$00.65
Hay, per ton	20.00
Oats per horse per day, one bushel	
Hay per horse per day, 35 lb	
Cost of feeding one horse one day:	
1 bu. of oats, 65 ct. per bushel	$0.65
35 lb. of hay, 1 ct. per lb	.35
Cost of feeding one horse one day	1.00
40 horses for 30 days, 1,200 horse days; 1,200 horse days at $1	$1,200

We have now described the various items that compose the cost of operating an elevating grader outfit and will proceed to summarize them.

SUMMARY OF COST OF IDEAL JOB.

Depreciation	$ 4,600
Interest	1,980
Supervision	2,500
Taxes	150
General expense	1,500
Winter expenses	2,065
Bond	600
Freight	1,000
Moving on and off work	800
Camp site	150
Cook house, five months at $100	500
Automobile expense, five months at $50	250
Running repairs, five months at $200	1,000
Labor, 5 months at $3,420	17,100
Industrial insurance, 3 per cent on $17,100	513
Horse feed, five months at $1,200	6,000
Total annual cost	$40,708

Dividing this amount, $40,708, by 70,000 cu. yd., the amount of material to be moved in the five working months provided for in the specifications under discussion, we get a cost per cubic yard of almost exactly $0.58, but this figure for the ideal elevating grader job includes the cost of 300 ft. of overhaul on every yard, and as your committee believes that $0.015 per cubic yard per 100 ft. is about the actual net cost of overhaul, we should deduct 3x0.015 or $0.045 from $0.58, making $0.535 the net estimated cost per cubic yard for performing the ideal elevating grader job.

Unit Cost of Ideal Job Without Profit.

In arriving at this figure, contingencies have been neglected, and we believe 5 per cent should be added to the net estimated cost to cover contingencies.

Net estimated cost per cubic yard	$0.535
Contingencies, 5 per cent	.027
Total estimated cost per cu. yd.	$0.562

This figure represents what in the opinion of the committee is the lowest cost at which work, such as we have described in the specifications for the ideal elevating grader job, can be performed under the prices for outfit, labor and feed that we used in our estimate, and we wish to emphasize the fact that the total estimated cost of $0.562 per cubic yard has not had added to it any amount for profit.

Profit.

The committe has discussed at some length the amount that should be added for profit and believes it cannot recommend any fixed amount, but must leave the determination of it to the individual contractor. In this connection, however, we wish to go on record as recommending that profit added should never be less than 10 per cent, nor more than 20 per cent of the total estimated cost.

Applying the Estimate.

We wish to impress upon our members that, when making use of this report, to guide their estimates of the cost of any proposed work, they must remember that work on the ground will seldom, if ever, be found that can be performed as cheaply as the work we have described under the specifications for the ideal elevating grader job; that each contractor, when he uses this report, must first revise our figures so they are consistent with the prces for outfit, labor and feed in effect at the time the work is to be done, and then make such additions to the cost arrived at as in his opinion are necessary to cover the differences between the actual work under consideration and the specifications for the Ideal Elevating Grader Job.

SCHEDULE "A" ESTIMATED COST OF ELEVATING GRADER OUTFIT.

1—only Standard Western Elevator Grader	$ 1,828.60
12—only 1½ yd. Western Dump Wagons at $263.05	3,156.60
2—only freight wagons, 3¾x12 skein ⅞x3 in. tire, 6,000 to 7,000 lb. cap., at $286	572.00
1—only tank wagon	285.00
1—only 12 in. Western blade machine	1,650.00
1—only Ford touring car	581.00
40—only horses at $225	9,000.00
20—only sets harness No. 425 J 2 at $102	2,040.00
2—only stable tents, 28x42 5 ft. wall, 12 oz. D. F. at $400	800.00
Managers for stable tent	150.00
1—only kitchen tent, 16x32 5 ft. wall, 12 oz. D. F.	260.00
2—only bunk tents, 16x24 5 ft. wall, 12 oz. D. F., at $200	400.00
1—only office tent, 16x24 ft. 5 ft. wall, 12 oz. D. F.	200.00
1—only cook outfit for 25 men	553.15
13—only steel bunks, 3 ft. 6 in. x 6 ft. 3 in., D. D., at $9.25 each	120.25
26—only mattresses, 3 ft. 6 in. x 6 ft. 6 in., No. 3, at $4.35 each	113.10
26—only 5-lb. pillows at $1.60 pair	20.80
80—pair common blankets at $3.85	308.00
1—only blacksmith outfit	237.56
Small tools	84.04
1—only No. 5 Western plow	45.75
2—only No. 2½ Western wheelers at $92.35	184.70
2—only No. 1 Fresno scrapers at $38.85	77.70
2—only No. 1 slip scrapers at $15.50	31.00
1—only Morman scraper	18.50
Lumber for blacksmith shop, etc.	100.00
	$22,818.05

Blasting Rock in Built-Up Sections

By JAMES VENESS.

I find that many contractors hesitate to use dynamite for blasting cellars in rock if other buildings are near by. It is my opinion, based on long experience, that damage to buildings, and especially windows, is almost always caused by loading bore holes too heavily or by trying to break up too great an area of rock in a single blast.

Of course, the temptation is strong to put down a number of holes, connect up the charges in series, and fire simultaneously to get the cumulative effect resulting from that method of loading. Of course, that is the economical way, the time saving way, the way that should be adopted when the excavation is a safe distance away from other structures, but otherwise single-hole shots and small charges should be the rule.

At the Kent School, New Milford, Conn., the cellar was to be 36 ft. x 26 ft., and 7 ft. deep. Rock extended 2 ft. above the ground; that is, 9 ft. of rock excavation. A 3-story glass-front building stood within 30 ft.

Several contractors refused the job because of the risks. By employing the following simple method, I got away with it without doing a cent's worth of damage.

Bore holes were drilled 18 in. deep and loaded with 1½ lb. of 40 per cent ammonia dynamite. Charges were covered with four or five railroad ties chained together and fired a single hole at a time. Only 70 lb. of dynamite were used on the job which was completed by three men in three weeks.

Feeders for Railroads

A paper with the above title was read by Mr. C. A. Morse, Chief Engineer of the Chicago, Rock Island & Pacific Railway Co. before the American Society of Mechanical Engineers in New York on Dec. 9, 1920.

The paper discusses some interesting questions which in the next few years must come before the Interstate Commerce Commission, the railroad managements and the public for settlement. Mr. Morse is to be especially commended for his very clear presentation of facts relating to the economy of abandoning many of our short, light traffic, branch line railways, for it is believed that the general public has been slow to see that in the long run they are paying a heavy price for them, a price out of all proportion to the benefits received.

The paper follows, very nearly in full:

Duplication of Service by Railways.—With a sane and common sense law by which the railroads are to be permitted to earn a fair return on the money invested in them, and the acknowledgment that the public must pay a rate that will give a fair return on the investment, it becomes the duty of the Interstate Commerce Commission and the railroad managements to make a study of the situation and to see, first, that adequate facilities are provided to give the public the best transportation possible and, second, to see that this is done at the least cost to the public.

In the past, due to unrestricted competition, many facilities have been duplicated, such as tracks from two or more railroads into the same industry; branches of two or more railroads running side by side where one railroad would do double the business done by all. The public should not have to pay the cost of maintenance and upkeeep, the cost of operation and interest on the investment, of duplicate property

There are many branch lines less than 50 miles in length that were built to control the territory on either side of a main line. In some cases there is another trunk line 75 to 125 miles away, running practically parallel, and both railroads have built branch lines down to about half way to the other line, in many cases on an agreement on a division of territory.

These were built, as a rule, in the days when there were ordinary dirt wagon roads and all teaming was done with animals. Today, with the advent of the automobile and motor truck, have come the so-called "Good Roads"; some of these are gravel surfaced, some macadamized, while many are what are termed hard surfaced roads with a roadway of concrete. The result of these roads, where built, is that passenger automobiles can travel 25 to 50 miles per hour and motor trucks loaded with produce or goods can travel 15 miles per hour, or practically at the same speed as branch line passenger and freight trains, and in all kinds of weather.

The Motor Vehicle in Competition of the Railway.—With the invention of the steam engine and its application to the vehicle, by which wagons could be propelled by steam power instead of by animal power, came the introduction of the rail on which to run the wheels, the rail being supported in different ways to preserve a level and smooth roadway. This crude power driven wagon which had sufficient power to haul one or more trailers has gradually developed into the powerful steam locomotive of the present day.

Later came the application of electricity as a means of power and the development of the electric locomotive. Both steam and electric locomotives are very expensive and they have to be very heavy, as they must haul a long train to be economically operated and they depend on adhesion to permit them to develop tractive power. The increase in the weight of the locomotive has required the strengthening of the roadbed and track on which it is operated.

The next power to be developed was the gas engine, designed to use either gas directly furnished or gas produced by volatilization of some liquid, such as alcohol, naptha, gasoline or mineral oil.

With the introduction of the gas engine came the development of motors of less weight which could be applied to lighter vehicles, and the result has been the automobile and motor truck.

The comparatively small cost of these motors has permitted their application to single units so that each unit could be operated independently. With the light, single unit power driven vehicles no rails are required; all that is necessary is a good, smooth surface that will support the heaviest truck.

The cheapness of the automobile and motor truck has been such that their use has increased until the horse is fast disappearing from road use. The almost universal use of these machines has made it necessary to provide a class of public roads over which they can be driven safely and rapidly in all kinds of weather. These are rapidly being constructed all over the thickly settled portions of the country.

It can readily be seen that with the introduction of a class of locomotive that requires no rails and which can be used by the public at large, that the use of the railroad, within the limits of the practical use of a single unit of transportation, must become less and less as good roads are constructed.

The public is paying for the good roads, they own the automobiles and motor cars, and now under the Transportation Act they must pay for the maintenance and operation and also the interest on the value of the branch lines of railroads. In many localities the passenger travel on the railroads, especially on slow branch line trains, has been reduced 50 to 75 per cent, due to the automobile.

If the public were required, as they should be, to pay a rate on the branch line that would pay the cost of upkeep, operation and interest on investment, it would pay as much in many cases as it costs to haul the freight to the main line by motor trucks.

Branch Lines and Improved Highways.—The public are going to be required to pay heavy taxes to cover cost of construction and upkeep of their good roads. Why should they, in addition to this, be obliged to pay in railroad rates the cost of upkeep, operation and interest on the cost of a branch line of railroad which they do not need, as with a good hard surfaced road and no branch line of railroad someone would operate a motor bus for passengers and motor express for less than truck load freight.

A careful study should be made of branch lines of railroads, and where there are "good roads" of the hard surfaced class, over which the business now handled by the railroad can be handled by motor trucks and buses, the question of dismantling the branch line of railroad should be given serious consideration.

Branch lines were formerly cheaply built, at from $12,000.00 to $15,000.00 per mile; they had narrow roadbeds, light rail, light bridges and less ties per rail than main lines; they were equipped with locomotives that had become too light for main line traffic, but handled the short branch line trains.

With the constant increase in the weight of locomotives on main lines for the past 15 years, there are no light engines to put on branch lines, and the result is that what are now perhaps light main line engines but are heavy for branch line service, are sent to the branches.

This, and the rapid increase in the size and axle load of cars, has necessitated the strengthening of branch lines with heavier rail and stronger bridges; more ties to the rail; wider banks and cuts; ballast has had to be applied; with the result that the $12,000 to $15,000 branch now costs $20,000 to $30,000 per mile, with the increased interest charge on the investment and the increased tax on the public to be added to their taxes for good roads.

Replacement of Branch Lines by Motor Bus Service.—The cost per ton mile for transporting freight and the cost per passenger mile on the short branch lines are far more than the amount received by the railroad, the result being that the revenue from main line business must be enough to pay for its cost, and in addition must be enough to cover the deficit on the operation of the branch lines.

If many of these lines that are tributary to a territory within the limits of auto bus and auto truck service could be taken up and abandoned, it would mean a reduction in the cost of main line service. Every large railroad has many branches of this kind which are simply feeders and do not reach any large towns or connect with an other railroad, which could be taken up with economy to the public.

Where branch lines are long enough that they cannot be replaced with motor service and do not connect with or cross other railroads, there should be a rate on the branch that would yield an amount sufficient to cover cost of upkeep and operation, and to pay the required return on the value of the line, as by this means the main line rates could be reduced, and there is no reason why the public at large should be required to pay an increased rate to provide cheap rates, cheaper than cost to produce, on a branch line to accommodate a few people. This is discrimination against the many in favor of the few, but it is one of the things that has been going on in this country for years.

In considering the question of abandoning a branch line, the first question that comes to the mind of the railroad man is how about the capital charge. Capital account would have to be credited with the book value of the line abandoned, and operation charged with the same less salvage, but this would be saved in direct outlay in a period of about five years and should be distributed over such a period.

After a careful survey of the situation on each railroad the useless branch lines should be listed and a program made up to cover a period of five to seven years, at the end of which period they would all be up and charged to operation, and capital account on which the public must pay a return would be reduced that much, and in addition the public would be relieved of the cost of operation, maintenance and taxes on those lines.

With the completion of such a program there would be a large reduction in investment in these useless branch lines, which would go a long way toward taking care of the investment necessary in the construction of lines that are required to develop new territory.

Branch lines are a necessity and it should not be understood that any attempt is being made to belittle their importance, but the transformation that is constantly going on in large cities in connection with the suburban train service, by which stations near the center of the city are abandoned, due to rapid transit on elevated railroads or subways, furnishing as good or better facilities, is also taking place where short branch lines are being operated, where the business can be taken care of as well, if not better, by motor cars on hard surfaced wagon roads.

The business of the country is constantly growing and it should be handled by whatever method gives the best service and the lowest rate to the public.

Some Advantages from Abandoning Branch Lines.—The abandonment of short branch lines of railroad and the delivery of freight at main line stations means an increased use of cars, as a car sent to a branch line station means, as a rule, a day going and a day returning to the main line, which is two car days lost for each car, which will be saved if the car is loaded at a main line station. The abandonment of these branch lines will do away with a lot of small mechanical terminals, which are expensive to maintain, also with men employed as station agents and helpers on the branch lines, and it will increase the force at many main line stations, where better supervision can be given to their work.

Tracks built to a single industry should be owned by the industry served and they should pay all cost of upkeep and all cost of operating the track, the latter as a switching charge that will cover the cost. Tracks that lead to several industries should be limited to a single industrial track, which should be operated by one railroad and all expense of upkeep and operation should be paid by the industries served by the line.

L. C. L. freight should be collected for all railroads at the various stations in the city and should be taken to a central point by one railroad or terminal company, and there made up into carloads and billed over the railroads to which it is assigned. The cost of this service should be kept separate and added to the carload rate from the consolidation point.

Those desiring to deliver L. C. L. freight to the point of consolidation by motor truck would save this special charge for collecting the L. C. L. freight.

The whole matter should be analyzed and worked out so that those getting special service pay for that service, and those who do not use the special service but perform a part of it themselves should not have to particpate in the cost of this special service.

In the effort to compel the reduction of rates, both the Federal and State regulatory bodies have encouraged the idea that the heavy traffic main lines were able to handle traffic so cheap that they should absorb the losses due to rates being too low on the branches, and to throw the whole line into a "jackpot" and strike an average of the whole thing.

In former times a differential often existed and branch lines had higher rates than main lines. Many lines have been detached during a receivership and in order to exist as an independent line they had to have higher rates.

Now that it has been decided that the railroads shall have rates that will pay the cost of production of transportation, this cost should be allocated as far as possible and the cost paid by those getting service.

With the special service paid for separately it will permit of a reduced rate for main line service from terminal to terminal, or from intermediate stations to terminals, which is what the vast majority of the people use. It will give the same saving that is made by the cash store that runs no delivery wagons. Why make the many pay for special privileges for the few.

The more dense the traffic on a given line of railroad the cheaper it can be moved per ton mile. A railroad line will, under present conditions, with the advent of the auto and truck, secure all of the business within 50 miles on either side.

In the western portion of the country there are large areas that are not within 50 miles of a railroad, where the quality of the land is just as good as that adjacent to the railroad, but which is not cultivated for lack of transportation facilities.

Feeder Lines into Undeveloped Territory.—There are many long lines of railroad which have not been provided with branch lines and on which the business is light, which could have a greatly increased traffic and at the same time assist in the development of the country if they would build feeder lines out into this undeveloped territory.

The lack of return on investments in railroads during the past 10 years has prevented these railroads from securing the money with which to develop the territory that naturally belonged to them, with the result that the cost per ton mile has been much more over these lines than they would have been with a proper system of feeders.

Some of the more prosperous railroads have systematically constructed feeder lines, and their prosperity under the adverse conditions was largely due to this policy having been carried out for a number of years previous to the strenuous years just previous to the war.

With the requirements of the Transportation Bill that the Interstate Commerce Commission shall pass upon all new extensions, railroads that have undeveloped territory adjacent to their lines which will warrant the construction of feeder lines and increase their main line business, thus reducing the cost per ton mile of all business over the main line, should apply to the Interstate Commerce Commission for authority to construct such lines and for a freight and passenger rate over the new lines that will pay the proper return on the investment and the cost of maintenance and operation of the line.

With the development of the country along a new line the business will increase, which will permit a gradual reduction in rates.

Suggestions on the Construction of Feeder Lines.—In the construction of such lines they should be located on the best grade line that the country affords, but in the beginning there should be inserted heavy grades and sharp curvature where it will make a decided saving in first cost; second-hand rail and obsolete and non-standard switch stands, frogs, etc., on hand by the store department should be used; station buildings of as cheap a class as possible should be constructed, exemption of taxes for five years should be secured from counties through which line is to be built and everything should be done that will decrease the first cost so that the rates can be made as low as possible while business is being developed along the new line.

Later, when the business has developed and earnings will permit, the class of structures can be improved, and should the line eventually be extended and become a main line the heavy grades and sharp curvature can be taken out at comparatively small expense.

In general, in building a line for developing the country, spend as little as possible to provide the means of transportation at as small a rate as possible, waiting for development before undertaking to make the line of standard construction.

In constructing branch lines they should be treated as independent lines, and all expenses incurred should be charged to them and not absorbed by the parent line.

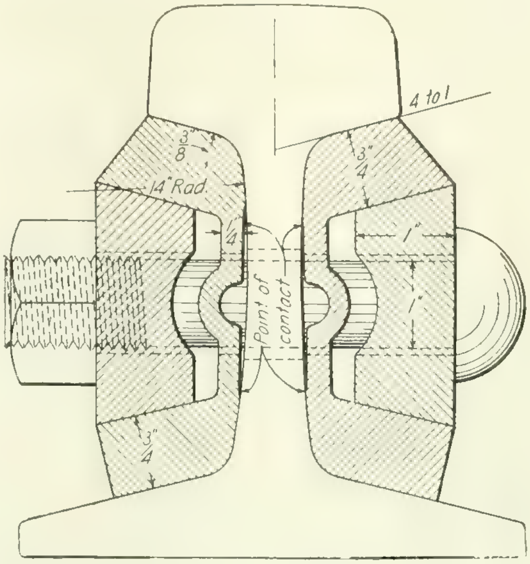
It has been the practice in many cases in the past to charge but a nominal freight rate on material for these lines and to make no charge for general expenses, interest during construction, services of general officers, etc. This should not be done in the future, as if these expenses are not charged to the new line they have to be absorbed in the operating expenses of the parent line. Each branch line should carry all charges for labor and material that is expended in connection with its construction.

The same methods should apply in maintenance and operation of the branch lines; all labor, material and freight for use on branch line should be charged to it.

A New Rail Joint

The illustration shown below, together with the description, are taken from a recent issue of the Railway Age.

The splice bars forming this joint are in two parts, the outer or channel-shaped part which engages the fishing surfaces of the rail and a smaller bar designed to fit the second fishing surfaces on the larger bar. The larger or channel-shaped bar is made with a relatively thin web which is curved, as shown in the drawing, to afford considerable resilience for the purpose of spreading the two flanges of the bar apart, as may be necessary to obtain the proper adjustment of the fit against the fishing surfaces of the rail and to take up such wear as occurs in these contact surfaces. The agency for accomplishing this adjustment of fit is provided by the smaller bars of the joint which, when forced together by tightening up the bolts, serve to force the channel-shaped bars into a snug fit, not only against the fishing surfaces of the rail, but also against a considerable portion of the web.



New Rail Joint.

Another feature to which attention is drawn by the manufacturers of this splice is that portions of this joint, such as the inner bars, may be renewed independently of the rest of the joint, thereby effecting a considerable saving.

Rail joints of this type have been in service on tracks of the Boston & Albany R. R. over a distance of two miles for two years and nine months, while nine other roads have recently placed orders for joints of this kind to be used on a mile or more of track, each for further tests.

Educational Plan for Railway Employes.—The Great Northern Railway Section of the American Association of Engineers has been asked by G. R. Martin, executive vice-president of the Great Northern Ry., and A. H. Hogeland, chief engineer, to assist in outlining and developing an education program for employes of that railroad. The executive committee of the section is collecting information and working out plans for a course. Professor Frederic Bass of the University of Minnesota, chairman of the A. A. E. Committee on Education, is acting in an advisory capacity to the committee.

Tractor Show at Columbus, O.—The 6th annual National Tractor Show will be held at Columbus, O., Feb. 7-12, under the auspicies of the National Tractor Show Committee.

Mud-Cell Dikes and Concrete Retaining Walls for Bank Protection

A paper by Mr. W. C. Curd presented before the American Society of Civil Engineers describes at some length an improvement made under his direction for the Natchez & Southern Ry. at Natchez, Miss. The work began in 1912 and was planned so as to extend progressively over several years; its recent successful completion came well inside the estimated cost. The following is abstracted from this paper as given in the Railway Review:

Previous to 1912 a row of piles was driven along the water's edge but this proved ineffectual as did some other schemes used so that bank was continually being lost.

Following the severe flood of 1912, an examination of the location was made and so much of the bank was found to be lost that it was considered imperative to take steps for relief.

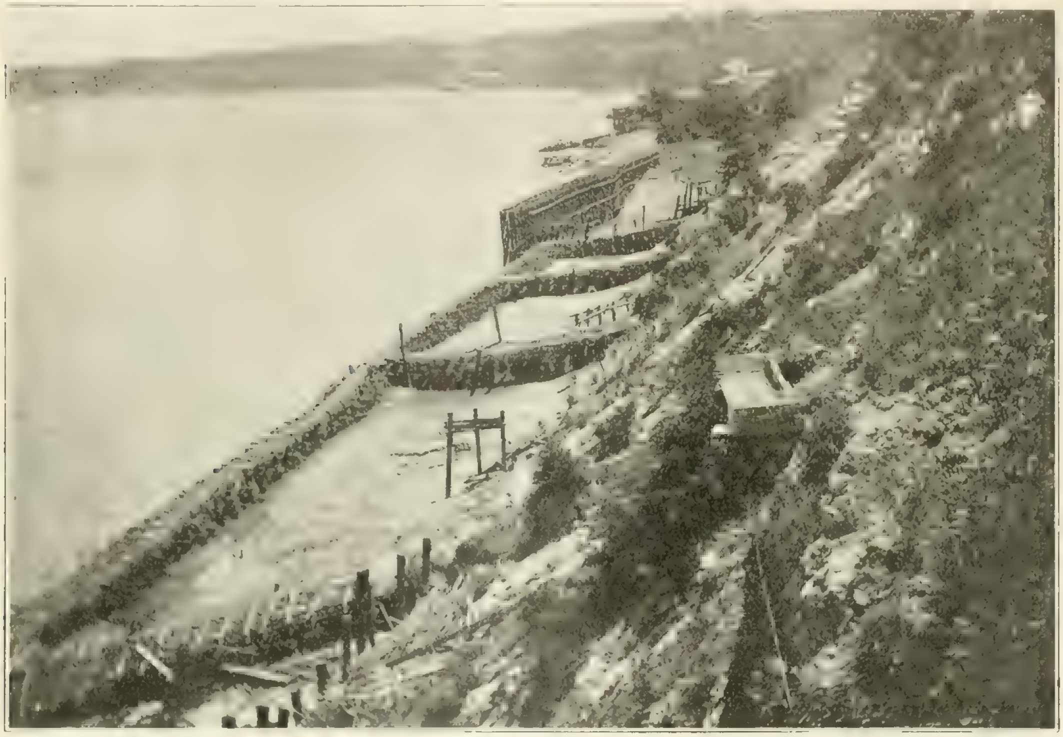


Fig. 1.—Completed Pile and Mud-Cell Dikes.

Surveys for a new location back in the hills were made, but the estimated cost of a new line was in excess of $150,000. It was deemed advisable, therefore, to make another effort to preserve the river-front location, which could be done, it was thought, at considerably less expense than that required for a new line.

The geologic formation of the Natchez hills consists of well-defined strata of clay, sand, and a deposit locally known as conglomerate of iron stone. The clay forms the surface covering, is very absorptive, and is 40 ft. or more in depth. The sand is clean and coarse, and lies between the clay and the conglomerate. The conglomerate outcrops slightly above low water in this location. It is dark brown in color and appears to have been deposited in a molten state. It is very hard and brittle, and where it is of any thickness satisfactorily resists erosion. Investigation showed that it lies in several layers, each separated by a light colored clay also of a quality not easily eroded.

The sand stratum being exposed along its vertical face was continually being ground away by the action of the elements. The clay was thus undermined and, when saturated by rainfall, would break off in large pieces and slide to the foot of the bank, carrying with it large quantities of the surrounding material. Very frequently after the slides occurred the fallen materials would take a natural slope at the foot of the hill, which for a time prevented further sliding or breaking away at the top. However, the lapping of waves, created by passing boats, soon carried away the toe, and the slides were repeated. During high stages of the river, at a gage of about 35 ft., direct currents would always set in and cause a rapid loss of bank.

The previous loss of so much bank made it apparent that the correction of the difficulty lay, not only in preventing further erosion, but in a restoration of the foot of the bank, so that a toe might be formed and a slope worked back to the brow of the hill. Material was scarce, as the few cuts along the track would not yield enough excavation to form the toe, and the expense of having such material loaded, hauled, unloaded, and placed in the right locations along the river-front was excessive.

Mississippi flood waters are always charged with sediment, and when the current is sufficiently retarded extensive deposits of silt can be secured. This fact, therefore, offered an economical solution of the problem of restoring the foot of the slope by taking advantage of natural conditions and producing sedimentation.

With the local conditions to be met, and having in mind his previous experience with various types of control works for producing scour and deposits, the writer decided to adopt mud-cell construction as affording about the cheapest means for getting results. The conglomerate offered a foundation secure against scour and one on which a deposit of required width and height could safely be carried. The problem then was to gather sediment from the river, deposit it to as great a height as possible, and hold it in position against erosion, so that future slides from the top of the hill would find a permanent lodging place and a stable slope be built up by casting over the side of the hill such material as would become available from time to time.

The design required that the improvement be carried out in two parts: First, to produce sedimentation; and, second, to protect permanently the slopes after sedimentation had progressed sufficiently. The first part called for the construction of a mud-cell dike with a pile dike at its head as a protection against direct currents; and the second, the construction of a low concrete toe or retaining wall with reinforced concrete slab paving on the slopes above.

In the fall of 1912, the mud-cell dike was constructed. It was 1,100 ft. long, 23 ft. high and from 75 to 100 ft. from the foot of the hill. The distance from the foot of the hill was regulated by the width required to give a 2 to 1 slope from low water to the top of the hill. The height of 23 ft. put the top of the dike at the 37-ft. level, Natchez gage, which was considered to be the maximum elevation to which sedimentation could be forced.

The mud cells were made from live brush and poles which were cut and towed from an island several miles up stream from the work. A 12-in. foundation mattress, 30 ft. wide, was first laid directly on the conglomerate. This was formed by laying the brush in bundles, or fascines, which were wrapped at 4-ft. intervals with single lashings of No. 9 galvanized wire. Anchor lines of ½-in. galvanized strand, spaced 50 ft. apart and woven into the mattress, were run back to deadmen at the foot of the hill. A tier of cells, 5 by 5 ft., was built on the foundation mattress by placing single rows of brush and poles at right angles to each other, very much after the fashion of a log cabin. At a height of 5 ft. the cells were floored over with a layer of brush and a second tier of cells was started 5 ft. back from the river face of the dike. Five tiers of cells were placed in this manner, forming a completed dike 28 ft., or five cells wide at the bottom and 5 ft., or one cell, wide at the top, and a settled height of 23 ft. All cell walls were bound with wire and cable to the foundation course, as well as to deadman at the foot of the hill. To prevent the cells from floating when submerged, they were ballasted with loose conglomerate picked up along the river-front. A connection with the hill at the lower end of the dike was made by joining the latter to an old abandoned transfer barge which had been sunk in line during high water just previous to the commencement of the dike.

Six lateral mud-cell dikes, or baffles, 15 ft. wide by 100 ft. long, were connected into the main dike and run up the hill to Gage 40 to prevent parallel currents and eddies in the enclosed area where sedimentation was being sought.

During the low-water period of 1913 the permanent pile dike to protect the mud-cell dike against head-water was completed. The dike extended from a point up stream to an outside lap connection with the mud-cell dike, a distance of 600 ft. The structure ranges from 8 to 42 ft. in height above the natural ground surface, the top being at an elevation of 56 ft. on the Natchez gage. It is made up in width of 112 lin. ft. with piles in single rows, 216 lin. ft. in double rows, and 272 lin. ft. in three rows, with 3½x10-in. white oak sheeting, spaced 2 in. apart, applied to the outer, or river, face of the dike. Cypress piles ranging in length from 32 to 62 ft. were used and 16 to 20-ft. penetrations were obtained through the conglomerate, under hard driving. The piles were spaced 8 ft., center to center, and driven in staggered position so as to gain additional strength against overturning. This necessitated an intricate system of bracing.

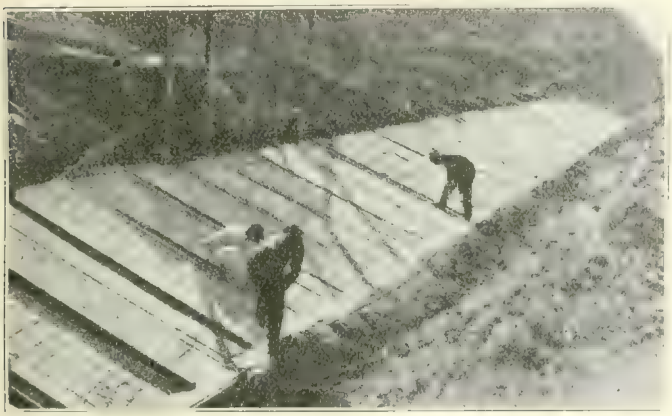


Fig. 2.—Slab Forms Complete with Reinforcing in Place, at Toe Wall.

The dikes were permitted to stand through the high water of 1914 and 1915 and until the low water of 1916 without additions or changes. When an examination was made in the summer of 1916, it was found that decay had begun to show among the brush and poles forming the mud cells, and as sedimentation had progressed to an extent that the enclosed area was practically filled and a growth of willows had appeared on the surface, it seemed advisable to proceed at once with the second part of the plan, the permanent protection of the slopes.

In preparation for the permanent slope protection, all the projecting ends of the brush and poles in the mud-cell dike not covered by deposits, were chopped away. The debris was deposited on the slopes for further use and a trench dug along the foot of the mud-cell dike for the toe wall. The bottom of the footing course was placed at about the 10-ft. level, Natchez gage, which gave a depth below the exposed surface of the conglomerate of from 3 to 5 ft., this depth being ample to afford protection against under-scour in this location. The toe wall was reinforced with galvanized mesh and carried to a gage height of 14 ft., at which elevation the concrete slabs were connected to it.

The bulk of the sediment recovered by the mud cells was deposited between the dike and the foot of the hill, and did not completely fill the cells. After removing the projecting cells, it was found that some filling would be required to bring the surface of the slope to the elevation at which concrete paving was to be placed. This condition was provided for by casting the slabs in place on supported forms. The slabs were 4 in. thick, 54 in. wide, 14 ft. long, and reinforced with galvanized mesh. They were placed on a 3 to 1 slope, and cast in alternate sections.

On all supported work the space underneath the forms was filled with debris from the mud cells. This was done to collect sediment during high water. As the first row of slabs was nearing completion, high water came and, as was expected, sufficient sediment was collected to fill solidly the space thus left. Figure 2 shows the toe wall, the method of supporting the slab forms, and the forms complete with the reinforcement in place ready for pouring the concrete. The flooring shown was made up in panels or sections which were removed after the concrete had hardened sufficiently to support itself. Formwork was unnecessary for the upper part of the slope, and the slabs were cast directly on the ground. The amount of paving constructed was 39,744 sq. ft., being 46 ft. wide on the slope, or up to a level of 33 ft., Natchez gage, and 864 ft. long.

A subdivision of the total cost of $38,741 between the three classes of work performed is as follows:

Mud-cell dike	$ 9,292
Permanent pile dike	10,604
Concrete paving and wall	18,845
Total	$38,741

Cross-sections of the amount of deposits obtained through the use of the mud-cell dike were taken, but the records have been lost or cannot be located at this time. However, it is the writer's recollection that approximately 56,000 cu. yd. of material were recovered. On that basis the unit cost of restoring the foot of the bank was 16.6 ct. per cubic yard, very much less than would have been required in that location by any other method. It must be borne in mind, in this connection, that had material from the hills been hauled in, some form of protection against its loss by high water would have been necessary until it had settled and the permanent paving was placed.

The general results of the work have been satisfactory, and all that could have been expected. A permanent toe has been furnished on which a proper slope can be founded, and the deficiency in the width of the brow of the hill can be filled out whenever the exigencies of the situation demand it. ◆

What the Railroad Accomplished in Nine Months

According to Mr. Thomas De Witt Cuyler, chairman, Association of Railway Executives the following things have been accomplished by the railroads in the nine months since the Government turned back the railroads to their owners.

1. Increased the average movement per freight car per day 6.3 miles—from 22.3 to 28.6 miles.
2. Increased the average load per car 1.7 tons—from 28.3 to 30 tons.
3. Made substantial reduction in the number of unserviceable locomotives.
4. Reduced the accumulation of loaded but unmoved freight cars from 103,237 on March 1, to 21,991 on Dec. 3, of which only 6,386 were detained because of the inability of the railroads to move them.
5. Relocated approximately 180,000 box cars from the east to the west for the movement of farm produce.
6. Relocated approximately 180,000 open top cars from the west to the east to keep up the production of coal.
7. Moved the third highest coal production in the history of the country.
8. Spent over $500,000,000 extra on improving the maintenance of tracks, bridges, cars and locomotives.
9. Contracted to spend about $250,000,000, largely out of earnings, for additions and betterments to promote the movement of cars.
10. Made arrangements to purchase approximately 50,000 new freight cars, 1,500 new locomotives, and 1,000 new passenger cars.
11. Begun the reconstruction of thousands of old cars.
12. Moved—with a deteriorated plant, under disturbed labor and business conditions—the largest volume of traffic ever known in a single year, with the highest efficiency yet achieved, and with a minimum addition to the value of the property on which the public has to pay a return through rate.

Creeping of Railroad Rails

In our issue of November 17th last there appeared an abstract of a paper on the above subject. The paper was presented by Mr. J. A. L. Waddell before the American Society of Civil Engineers on Nov. 3rd. Some discussion on this paper has since appeared in the society bulletin, from which the following has been taken:

Mr. Orlando Metcalf believes that the difference in height of rail ends at the joints, even though it is a very small fraction of an inch, emphasized as it is under traffic when the wheel load is on the delivery end of the rail, each wheel of the entire train striking the slightly higher receiving end with trip-hammer blows, must be a considerable factor in the forward movement of the rails. Attention is called to the fact that in some cases rail anchors in insufficient number or in the wrong place have failed to prevent creeping.

Other members of the society offered experience opinions and results of observations, as follows:

Discussion by Leonard C. Jordan.—One point which seems to have been overlooked in the questions and answers is the fact that when steel creeps up grade on a single-track line, due to unbalanced traffic, this tendency is far greater at the lower end of the grade than elsewhere. Up-grade trains have a greater velocity at this point than farther up, due to running for the hill, and down-grade trains release brakes before reaching the bottom, thereby relieving the skidding tendency. These factors combine to cause greater creeping at the bottom of the grade than higher up. Furthermore, on account of the greater speed of trains and the inferior track at this point, due to a combination of fast trains and fast creeping, this track is generally the part of the grade which is most troublesome and, therefore, most noticeable, a possible reason for the frequent statement that steel creeps up grade rather than down.

As a cause of down-grade creeping, the force of gravity is fundamental, though indirect. Down-grade trains apply their brakes and thereby exert a skidding force on the rails, while there is no counteracting effect of up-grade trains. Down-grade engines merely coast, while the entire tractive effort of up-grade engines tends to snake the steel down hill; and the average train velocity is greater on down than on up grades. Independent of other influences, these factors tend to affect down-grade creeping.

In this connection there is the pertinent question as to whether any one has observed whether a hard pulling, up-grade engine with a slow train actually pulls the steel down grade while the train effect reduces or reverses the result. Dependable data on this question might be enlightening.

The writer frequently has laid down very close to the track in order to sight along the rail while a slow train was passing. The appearance of these waves, as they move along with a high point under each car center, would seem sufficient to account for a large part of the creeping. The length of the rail in a wave between trucks is greater than the straight-line distance between the same points. The difference between these lengths measures the actual creep per car due to wave action because, as it advances, each truck rolls all points of the rail down to a straight line. When a car is so long or the track so flexible that the top of the wave assumes the normal unloaded position, then it would be difficult to imagine that a greater car length would further increase creeping. Creeping, however, will be reduced by car lengths so short that the wave amplitude is reduced. Probably the impact due to high train velocity causes deeper depressions under the trucks, or greater amplitude of the wave, and, therefore, greater creep. Yet we must not lose sight of the fact that there are other causes of rail creeping, and that wave motion is merely one influence.

As a mathematical illustration of wave effect only, if a wave is composed entirely of circular arcs of equal radii and the length is 20 ft. between wheel centers and the height is 2½ in., the hypothetical creep is 1/16 in. per car. Less amplitude and a sharper curving near the wheels, a more probable condition, might easily cause a greater creep. Although Dr. Waddell has very properly excluded mathematics from this discussion, it is proper to point out that the wave effect per car can be only a small fraction of an inch rather than something more alarming. Yet from this cause alone a wave effect of only 1/100 in. per car would result in a creep of ½ in. for each long train.

Dr. Waddell suggests an occasional substantial anchor by driving piles between ties or by planting a "dead man" under the track. There is a serious objection to such a plan. There would be an opening of joints beyond each anchor and a buckling tendency just back of it. The severe strain thrown into one rail joint very probably would cause a dangerous break at a critical time. Such anchors would have to be at frequent intervals to be effective, which would be costly. Also, the proposed spacer blocks between ties would be loosened by each slight reversal of creep.

It is time to point out the strange fallacy of laying rails with broken joints. Jints are sure to get low at times, and when they are staggered, they give cars a rocking motion which tends to throw the rails out of line, while even joins merely cause a vertical vibration. Also, with even joints a relatively better support can be provided by choosing the largest ties for the joints during renewals. With even joints there will be no slewing of ties by creeping steel, such as is cited repeatedly in the paper.

Old, experienced track foremen argue that for these reasons the change to staggered joints from the earlier practice of even joints was an unpardonable mistake. It is sometimes contended that the presence of at least one rail continuous past any point of track provides lateral rigidity. The absurdity of this notion will be recognized readily when thought is given to the extremely small lateral strength of any standard rail. No considerable rigidity can be given to the track by a rail so flimsy that an ordinary man can deflect it into a sharp curve by the strength of only one hand, as is done by lifting an end of a rail when lying on its side.

There seems to be a general agreement that creep will be eliminated when there is a rigid connection with several ties per rail. The usual forms of anti-creepers are effective in only one direction, and they are loosened when even a small amount of creep occasionally takes place in the reverse direction. The solution then would seem to lie in a rigid attachment gained by bolting splice-bars to the rail at the center and by slot-spiking to the ties. For this purpose some foremen use the halves of broken splices. When even joints are used there is no slewing of joint ties. Such intermediate splice-bars also act as rail braces and thus give additional strength to the track. If this practice should prove to be generally adopted, it would be well to roll a light section splice-bar which would serve this purpose as well as the standard bars, and which would be considerably cheaper than a bar heavy enough to form the splice.

In the writer's opinion there is ample opportunity to put an end to ordinary creeping by a different arrangement of the joints. By using even joints and special tie-plates extending over two or three ties at each side of the joint, all tendency to creep would be communicated to several ties, as many ties as would be found necessary. These tie-plates should be merely long lengths of the plates from which the shoulder type tie-plates are sheared. They would have holes for spiking to all ties just like any tie-plates. The rail anchorage would be formed by heavy spikes, preferably screw spikes, into the joint ties and through the splice-bar slot. There would be no slewing of ties, and the arrangement would be equally effective in the two directions. The cost of such tie-plates would be small, as there would be no field drilling and no other special work. The plate would replace nearly half its length of shorter plates of the same section, a plate extending over six ties would weigh only about 50 lb. more than the small plates replaced. This plan surely is worthy of a trial before being rejected as inferior to some device more costly and less certain of producing the desired results. The addition of a clamp between the joint ties and holding the plate to the splice-bar flanges would strengthen the joint to some extent.

Discussion by F. W. Green.—Although the causes of creeping rails may be more or less obscure and possibly various, the writer has reached the conclusion, in his own mind, that rails creep because of the resistance to traction of care pulled by a locomotive. To make the principle clear, imagine the wheels of the cars locked by brakes being set, on level tangent track, and with a static coefficient of friction 0.34. For each tone of weight on the wheels, the force necessary to move the cars would just equal 0.34 ton. After movement started, of course, the coefficient of friction would become dynamic, instead of static, and would decrease inversely with the speed. With a tractive force of 0.34 ton, the rail could (a) remain perfectly stationary, and the car slide on the rail, or (b) the car could slide and the rail slide, or (c) the car could remain stationary and the rail slide. In any event, the force would be exercised along the line of lease resistance.

With the brakes released, assume that the cars are loaded so as to produce, say, 5 lb. per ton tractive resistance. The tractive force necessary to move the cars now becomes $\frac{5}{2\,000}$ or 0.0025 ton. Here the same three phenomena, as mentioned previously may occur; (a) car move with the rail stationary; (b) car and rail move; or (c) rail move with the car stationary, relative to the rail.

It will be observed at once that the tendency of the rails to move increases as the traction resistance increases, from which it follows that a train moving with considerable weight and speed, with air-brakes applied, will probably increase the tendency of the rails to creep.

In the writer's opinion, however, the tendency of rails to creep is greatest in the vicinity of curve except possibly on long, descending grades, where the speed of the train has to be controlled by air-brakes. It is customary on all railroads to super-elevate the outer rail on curves for passenger train speeds. Any train passing over the curve at the precise speed for which it is elevated will have equal wheel reactions as between the inside and outside rails. Freight trains ordinarily traverse curves at slower speeds, and as the speed decreases, the wheel reaction becomes less than one-half the weight of the truck for the outside wheels, and correspondingly more than one-half the weight of the truck on the inside wheels. By reason of the length of arc on the inside rail being shorter than the arc on the outside rail for equal angles subtended at the center of the curve, there is a tendency for the inside wheels to run ahead of the outside wheels. In other words, the axle joining the wheels will not be radial. The inside wheels will continue to run ahead until the flange pressure on the forward outside wheel and the rear inside wheel of the truck reaches a point in excess of the weight carried on the wheels, multiplied by the coefficient of friction. At this point the truck must rotate in an approximately horizontal plane, and one of two things must happen; (a) the outside wheel slide forward, or (b) the inside wheel slide backward.

It is believed that when freight trains traverse curves at speeds less than those for which the curves have been superelevated, the outside wheels carrying the lesser load will slide forward. When this ocurs, the tendency of the outside rails to slide in the direction of the train movement is augmented materially. Incidentially, when this occurs, it is believed that the rolling effect on the inside rail occurs, which causes the top of the inside rail to flatten out and produces what is commonly called "fins." It is blieved that this explains why rail will run at certain parts of the line in one direction on one side to a greater extent than on the other.

The writer has found that a very effective way of reducing the creeping of rails is to maintain the track gauge at 4 ft. 8½ in. on curves. As the gauge is permitted to widen, the trucks make longer chords before slewing, and when slewing occurs, it is with some violence, not only increasing the rail wear, but also increasing the creeping.

It would be interesting to know whether the tendency which the writer has observed, and from which observations he reaches the foregoing conclusions as to the cause of creeping rail, has been observed, with similar results, by others. It has also been the writer's experience that the tendency to creep is much less marked where the rail has been laid and maintained with proper expansion. Where maladjustments of expansion occur, the tendency for rails to creep is especially marked, and the difficulty of anchoring it successfully against creeping greatly augmented.

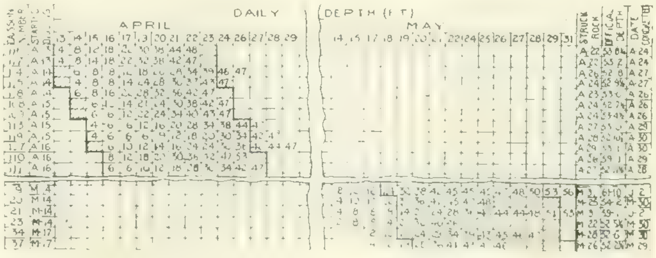
Discussion by B. H. Bryant.—Sixteen years ago the speaker left a certain railroad, at which time the trouble that resulted from creeping rails had not been entirely overcome. He is convinced that this was due to the poverty of the company, which prevented the general application of the plan that was finally adopted to deal with it. This plan was not a complicated one, as it consisted of having sections of angle-bars rolled and cut into short lengths, about 5 in., or long enough to stagger the slots in the base of each pair of short angle-bars to correspond with the standard angle-bars and suit the punching in a joint tie-plate. These short angle-bars were bored for a track-bolt, and the rails were bored with a track drill to permit the application of two or three pairs of the bars to each rail; by this system each rail was firmly anchored to four or five ties, and the result was most gratifying. The speaker is of the opinion that if the number of ties to the mile of track is increased as the average size of the ties decreases, if every tie is tie-plated, if all spikes at the joints are driven in the slots in the angle-bars, and three short angle-bars are attached to each rail in the manner outlined, the creeping of rails on the ties will stop.

It might be added that if angle-bars with wide flanges, that permit the punching of a perfect hole in the flange, instead of a slot, are used for both the standard and short bars, a firmer anchorage of rails to ties will be secured than is possible with slotted angle-bars. If creeping track takes the place of creeping rails as a result of the more secure fastening of rails to ties, the situation will become serious and some of the other expedients mentioned by Dr. Waddell will have to be adopted.

Chart for Recordiug Progress in Caisson Sinking

In order to show readily the daily progress in foundation work during the construction of the mail-order building now being completed in Winnipeg for the T. Eaton Co., Ltd., the shart shown below was devised by H. L. Small, resident engineer at Winnipeg for Graham, Anderson, Probst & White, who are the architects in charge of the work.

The complete chart used by Mr. Small is not shown, as it was very long and charted a large number of caissons, the sinking of which proceeded continuously, three or four new caissons being started daily. All of the important characteristics of Mr. Small's chart are shown, however, in the accompanying diagram, which gives the record of two groups of caissons, one group begun and completed at the commencement of the work, and the other group begun and completed near the close of the foundation work, the records of the intermediate caissons being omitted from this diagram.



Caisson Progress Diagram.

The general utility of the chart is readily evident. In the first two columns are set down the caisson numbers and the dates upon which excavation is started. Then, under the appropriate date, and opposite the caisson number, at the end of each day the engineer records the depth to which the caisson has been sunk below the top of the lagging, which in turn is referred to grade. In the three right-hand columns are recorded the dates on which rock is struck, the official depth below grade, and the date of concreting.

To show daily to what extent the work is proceeding in exact accordance with the pre-determined schdule, stepped lines are drawn down the chart, outlining the tentative or scheduled starting and finishing dates for the sinking of the various caissons, ten days being allowed for the sinking of each caisson.

Deviation from the schedule is shown at the beginning of the sinking of a caisson, if it be on the side of lateness, by shaded blocks at the right of the tentative starting line, as for caissons 114, 115, 108, 109 and 107. If the sinking begins earlier than called for by the schedule, depth figures at the left of the stepped line indicate such priority, as for caissons 9 to 37, inclusive. When work on a caisson is finished in advance of the schedule, a shaded block is drawn at the left of the finishing-date (or right-hand) stepped line, as in the case of caissons 116, 117, 118, 110, 20, 23, 34 and 37. When work is completed later than time schedule, depth figures appeared on the right of the right-hand stepped line, as in the case of caissons 114, 115, 113, 119, 107, 9 and 21. We are indebted to The Canadian Engineer for the above illustration and description.

Experiences in Pile Driving

Some interesting points on pile driving were given by Col. Charles R. Gow of Boston, Mass., in an informal discussion Oct. 20 before the Boston Society of Civil Engineers. The discussion is printed in the December Journal of the society, from which the matter following is taken:

The question of whether or not piles can be successfully driven through certain classes of soils is one upon which there is much disagreement. In an experience covering several years, during which the writer has had occasion to excavate to considerable depth in various sections of this locality (Boston), he has been impressed with the great number of instances where broken or damaged piles have been uncovered. Especially has this condition been noticeable in those districts where there exist considerable deposits of coarse gravel filling, through which the piles must penetrate in order to reach the natural underlying soils. Take for example the section known as the Park Square railroad property. This area was formerly a portion of the Back Bay marshes. The flats were reclaimed by depositing over them gravel filling to a depth of from 15 to 18 ft. The original surface was of mud extending to a depth of from 15 or 18 ft. more, and was underlaid with a natural deposit of blue clay into which piling must be driven in order to obtain a satisfactory bearing. The gravel filling has been thoroughly consolidated, so that it would probably offer a satisfactory resistance against settlement under ordinary conditions of loading were it not for the existence of the silt below it which renders the use of some form of piling absolutely necessary. To penetrate the silt a pile must first be driven through this upper layer of coarse gravel, where great difficulty is encountered.

Observation of many piles uncovered in this general locality indicates that a very large proportion of the piles fail to penetrate this gravel stratum. Apparently, the pile tip as it advances through the gravel carries ahead of it a large number of stones and pebbles which ultimately are gathered into an enlarged mass, preventing further penetration. Further driving usually results in some form of damage to the piles. Sometimes the tip is broomed and mushroomed into a mass of crushed fiber; again the pile may fail by diagonal shear or by telescoping one part upon another; frequently these piles are found with their lower portions broken off and deflected laterally almost at right angles.

In one case, in which the writer encountered difficulty in driving piles through this material, the trouble was overcome by sharpening the pile tips almost to a point, so that the several stones encountered would be deflected to one side and not carried down in advance as in the case of the ordinary tip.

There are many authorities who claim that wooden piles can be successfully driven through stone rip-rap. The writer has uncovered a number of piles in his experience which have been driven into rip-rap but never has he found one which has penetrated such material for any considerable depth. In such cases the tips of the piles are soon deflected in one direction or another, as they encounter the inclined surface of the stones constituting the rip-rap, with the result that they become broken and broomed into a mass of pulp. It is probably true that such piles obtain a sufficient hold by means of this brooming so as to maintain them in place, but if there is unsuitable foundation material under the rip-rap the piles will be of no assistance in overcoming its effects.

A very common cause of failure on the part of piling to carry its load is the stopping of the piles before good bottom is reached. In many instances such piles develop apparent resistances to further driving due to the high frictional units developed in some of the upper layers of soil penetrated. This may easily lead to the assumption that the pile has brought up in good soil, when as a matter of fact the tip still remains in poor material. Under such circumstances the load applied to the pile is transmitted to the layer of filling possessing the high frictional value and is further distributed by this stratum on to the soft underlying soil which slowly yields under the pressure, causing ultimate settlement of the structure.

When the pile tip brings up in a sandy or gravelly soil there is usually no difficulty in securing the necessary resistance required to carry the load safely. When, however, the supporting medium is of clay, there is often some question as to when it is safe to stop driving. Clays are usually of a plastic nature, and generally speaking are apt to be stiffer when first encountered than at a greater depth. It is usually possible to drive piles into clay to any desired distance with little variation in penetrations under successive blows. It is also commonly found in this locality (Boston) that in attempting to apply the Engineering News formula to such cases, they frequently do not give satisfactory results. If, however, the pile is permitted to remain undisturbed for a few hours, it will require several additional blows to produce again the original penetration, and if the formula is applied to these re-driving results very high load values will usually be obtained. In explanation of this phenomenon it may be said that during the original driving a rough and irregularly shaped hole is made in the clay by the projecting surfaces of the pile. As soon as driving ceases, the clay closes in around the pile, completely filling each depression and crevice, and gripping the pile surface so firmly as to offer an enormous resistance to further penetration.

During the construction of a pile wharf at the Boston Army Supply Base, some long piles were found extremely deficient in carrying power by the usual application of the driving formula. One 40-ft. pile when driven to grade gave a 10-in. penetration, indicating a safe carrying capacity of only 4 tons, whereas it was designed to carry 15 tons. A test load applied to this pile showed no settlement at 12 tons and only a slight settlement at 18 tons. The 12-ton load was adopted, and has since been carried without any indication of overloading.

Similiar conditions were encountered in driving foundation piling for the wet slips of the Victory Destroyer Plant at Squantum. Piles which gave values of not more than 2 to 3 tons by application of Engineering News formula subsequently supported test loads of 10 to 12 tons without appreciable settlement.

A more recent example of similar behavior of piling driven into soft clay was noted in connection with the pile-driving operation at the new John Hancock Bldg. at the Back Bay district. In this case many piles gave initial penetration values for last blows of from 5 to 7 in., whereas redriving tests after a set of 24 hours reduced these figures to from ⅛ to ¾ in.

All of the instances cited to show that the usual driving formula is very conservative when applied to the soft clays of this locality. Of course the greater the depth of embedment which a pile has in such clays, the more certain one may be as to its sufficiency.

Vibration may often be an aid to the settlement of piles, and its effects should be guarded against. When structures are subject to vibratory forces the impulses may readily be transmitted to supporting piles, and in such cases piling which has successfully carried its designed static load may yield under the influence of the vibrations which tend to disturb and alter the condition of the soil immediately adjacent to the piles. Under such circumstances, deeper penetration and lighter loading are indicated as probably desirable.

The splicing of piles where extremely long sticks are required is often necessary or desirable. The joint between the sections may be secured by a variety of methods. An ordinary carpenter's splice, when the ends are halved into one another and bolted, probably gives the strongest and also the most expensive splice. A simple mental sleeve if of sufficient length and thickness is also effective. Oftentimes the two ends are butted together and spliced with outside cleats, just as splints might be applied. In some cases no other precautions are taken than to dowel the two ends together, using the top section as a follower to drive the advance section.

If the spliced pile is driven in a perfectly straight line and the soil is such as to introduce no deflecting forces, such piling can usually be successfully driven, regardless of the type of splice used. If, however, the driving is difficult and there are tendencies which cause the pile to deviate from a straight line during the process of driving, the splice must be as strong as the balance of the pile or failure at this point is likely to result.

When long piles are driven in very soft material, and additional resistance is required beyond that developed, the result may usually be accomplished by lagging the pile vertically with 2-in. by 4-in. or 4-in. by 6-in. strips bolted to it. This serves to increase the surface exposed to frictional contact with the soil and likewise produces added compression in the surrounding soil because of the greater displacement.

Sometimes it becomes necessary to drive piles through water in locations where the bottom is difficult to penetrate. Such piles may be rendered stable by depositing rip-rap around them. In other similar cases it may be desirable to remove the hard material by dredging and to backfill the space after the piles have been driven.

The use of a follower in driving piles is not always deemed satisfactory, but there are many cases where its use may be beneficial. In driving into clay or plastic soils, it is usually possible to bring the pile heads to any desired elevation, because in such soils the resistance seldom reaches the point of absolute refusal. A follower may sometimes be used in such cases, allowing the pile to be driven from the original surface and its head stopped at the desired grade, eliminating the cutting of the piles and permitting the pile driving to proceed the excavation. This method was successfully adopted some years ago during the construction of the Merropolitan High Level Sewer at Hough's Neck, Quincy. The same piling contractor later drove foundation piling for a section of sewer in Chelsea, the driving being followed down through a considerable depth of silt which closed in and filled the hole after the follower was withdrawn. A compressed air tunnel was subsequently driven over these piles, and a masonry sewer constructed, for which the piles served the purpose of a foundation.

Railway Construction in 1920

The mileage of new railway completed in 1920 was less than half of that for the previous year, according to statistics collected by the Railway Age. During 1920 only 313.7 miles of first track was completed, as compared to 686 miles in 1919, while the total completed mileages (first, second and other multiple main tracks) for the two years were 414.3 and 1,355.7 respectively. The most important decrease, however, or at least the one having the most bearing upon the operating efficiency of the roads was that concerned with the construction of second, third and other main track. For second track this fell from 681.55 miles in 1918 and 405.32 in 1919 to but 90.87 for 1920. Only 1.89 miles of third track were built as compared with 76.95 in 1918 and 27.54 in 1919. The decrease in the construction of other main track was equally as marked. In Canada there was some decrease in total mileage constructed as compared to the year 1919, but a considerable increase over that for the years 1917 and 1918. During 1920, 305.39 miles of new lines and 31.60 miles of second track were built, or a total of 336.99. While lower than the 442.4 miles of 1919, it indicates a resumption of the policy of expansion which the Canadian roads have been following in tapping and building up new sections of the country.

The following table from the Railway Age shows the new track built in the various states in 1920.

		Miles		
United States	No. Co's building.	First track.	Second track.	Total.
Alaska	1	37.00	. .	37.00
Arizona	1	5.00		5.00
Arkansas	2	9.00		9.00
California	5	54.74		54.74
Colorado	1	.....	1.10	1.10
Florida	2	12.20	. .	12.20
Georgia	2	5.00	.	5.00
Illinois	1	2.00	36.54	38.54
Kansas	1	0.50	.	0.50
Kentucky	4	19.87		21.67
Louisiana	3	31.15	.	31.15
Maryland	1	2.72	.	2.72
Michigan	1	.....	0.50	0.50
Mississippi	1	9.52	.	9.52
Missouri	2	0.86	11.85	12.71
New Jersey	2	1.97	2.24[2]	5.95
New Mexico	1	9.00		9.00
New York	1	1.46	1.46	2.92
Ohio	1	1.35	27.24[3]	34.67
Oklahoma	2	18.00	. .	18.00
Oregon	4	8.60	.	8.60
Pennsylvania	4	6.12	0.39[4]	6.66
Tennessee	1	2.50	.	2.50
Texas	3	54.90	1.70	56.60
Utah	1	3.60	.	3.60
Virginia	1	0.20		0.20
West Virginia	3	16.45	1.75	18.20
Wisconsin	1	.....	6.10	6.10
Total	53	313.71	90.87	414.35
Canada	7	305.39	31.60	336.99

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[1] 1.80 miles of third track also completed. [2] 1.74 miles of fourth or more track also completed. [3] 0.09 mile third track and 5.99 miles fourth or more track also completed. [4] 0.15 mile of fourth or more track also completed.

Railway Terminals and Yards

An interesting discussion of a very important subject was presented at the annual meeting of the American Society of Mechanical Engineers by Mr. Wm. Barclay Persons, of New York City. While perhaps of particular importance and interest to New York engineers, the following abstract of Mr. Parsons' paper should appeal to others, as similar problems are certain to present themselves in other large cities in the future.

Terminals form the largest item in railway construction cost and the most expensive item of cost in railway operation. What proportion of the total cost is represented by terminals and terminal yards is impossible to say, but a high official of one trunk line entering New York recently made the guess that perhaps the reproduction cost of their end and intermediate terminals, together with equipment, would be as much as all the remainder of the road with its equipment. On the average, does it seem unlikely that at least 30 per cent of the physical valuation of the railways in the United States would be represented by terminals and terminal yards? Any figures short of a detailed valuation must be a guess, though a guess based on experience.

To make a similar guess as to the cost of terminal operation would be more difficult and with perhaps a less accurate basis. There is no segregation of cost figures that will give a reliable estimate as to how much of the total expense of transportation is absorbed by the terminals as compared with that absorbed by train transportation on the open track. The ratio will obviously depend on the length of haul, being greater when the haul is between nearby points such as Philadelphia and New York and less when between Chicago and New York; but on the average can it be safely put as less than the estimated construction cost ratio of 30 per cent?

Again, the writer would like to give figures as to such cost of final delivery, but conditions vary so much in different cities that no reliable statistics can be given. Several investigations have been made in New York and one established the figure of cost of trucking from the railway freight house to the consignee's warehouse as amounting to as much as 80 per cent of the whole railway charge for carriage from Buffalo or Pittsburgh to New York. Place any figures you like within reason as the part of the total railway charge that should be allocated to the cost of passing a car through a New York terminal yard and the unloading of the goods, and it is evident that it costs much more to handle a ton of freight through New York to the point of ultimate destination than it does to haul that same ton some 400 miles, including in the latter expense the cost incurred in handling the goods in the originating and intermediate terminal yards.

In regard to proper charges for the use of terminal facilities, it is obvious that rates can be raised so high that the resultant gross returns will show declines and not increases. Managers must therefore see that rates are not carried beyond the critical point, or, to put it another way, they must see that business is conducted economically. But that responsiblity is also placed on the shipper. If he would avoid further raises in rates he can aid by focusing public attention on the unnecessary burdens placed by legislation on transportation companies, on the failure of the transportation companies to use their properties in the best manner to produce the most economical results for all concerned, or on the failure of public authorities to co-operate with the transportation companies and with each other.

How can savings in terminal expense be obtained? In the old competitive days it was necessary for each company to have its own complete terminals and to prevent competitors from obtaining facilities as ample or so well located There resulted, consequently, as many terminal yards as there were companies, and frequently each terminal yard had its own separate arrangement for the handling of every class of commodity. Under the present law the systems are not actually combined, nevertheless the cut-throat competition has been removed, and the companies are not only free but are encouraged to eliminate wasteful duplication. The Chicago Terminal Commission has already answered this question by saying that "there are decided advantages in co-operatiive operation."

In 1918 railways in different parts of the country began to put such co-operative operation in effect and reports show that savings of very measurable proportions resulted. In the northwestern, central-western and southwestern sections covering twenty-eight states, estimated annual savings amounting to $5,750,000 have already been obtained. Would there not be really great savings if all the terminal facilities in all our cities should be pooled and duplications be avoided?

The question has been put, "What can the railways do to reduce the cost of terminal operation?" The complement question can also be put, "What can the shippers do?" A few years ago shippers used both railway freight houses and cars as places of free storage for long and indefinite periods. High demurrage charges rigorously enforced, however, have greatly reduced this irregular and wasteful proceeding, and in fairness to all parties it should be stopped entirely. There is perhaps only one way in which this can be done and that is by having the railway companies do all the unloading and delivery, either by their own agencies or by some authorized single agent acting for them. To cover the cost of this delivery service, freight rates would have to be raised correspondingly, but the total would be much less than the present cost to shippers, which is a combination of the railway charge and their own trucking expense.

At a meeting in New York where terminals are being discussed one cannot refrain from speaking of New York's terminals, nor is it proper to refrain because New York's terminals are really the affair of the whole country. In what can be called the Metropolitan District, embracing a part of New Jersey as well as the city of New York, there is located nearly one-twelfth of the whole population of the United States, and this same district is the greatest manufacturing center of the United States. Forty per cent of the export and import traffic of the whole country passes through the port.

There is but one railway whose freight tracks reach Manhattan Island. All the other lines maintain the connection by lighters. One hundred years ago it was the Hudson River that furnished an outlet for the Erie Canal and carried New York to the first place among American cities, thus establishing its ever-increasing commercial supremacy. On the advent of railways they, one by one, except the Hudson River Railroad, located their terminals on the Jersey shore and lightered their traffic across the water. As their business developed they increased their facilities, and as the city grew they created new points of delivery, but always maintaining their separate and individual identities. The consequence is that every railway coming from the West maintains on the Jersey shore great yards occupying valuable space whence freights are transferred by floats to various points not only on the edge of Manhattan Island, which was New York when railway traffic originated, but to the greater parts of what is now New York, namely, Brooklyn, Long Island and the Bronx.

Is this necessary? If it is not necessary, is it the best and most economical arrangement? Should not the terminal facilities of the several roads be pooled, thus concentrating operation on the part of the railways? Instead of maintaining special delivery stations in New York, can there not be a combining there, with perhaps a further segregation into places for delivery according to commodities? If the principle of "store door" delivery be adopted there seems to be no necessity for water-front terminals in New York and water-front yards in Jersey. New yards with switching connections at both ends can be constructed with modern freight houses and unloading tracks equipped with labor-saving freight-handling machinery. These could be located in any convenient place, even on the wide expanse of the Jersey meadows. To them motor trucks with trailers carrying not part but full loads would transport merchandise between cars and points of origin or destination in any part of the Metropolitan District. In such a system would there not be economy in handling, time saved in trans-terminal shipments and a relief to street congestion through diminished number of trucks? The first two are for the immediate benefit of the railways and shippers, but the last is for the benefit solely of the city.

There is a fourth advantage in which the nation as a whole and the Metropolitan District would share jointly. Already New York's harbor terminal facilities are overtaxed and there is danger of surplus foreign traffic seeking against natural laws other and consequently less well-situated ports. The freeing of such a large area of water-front property now held for local freight purposes only would render available a site for the finest kind of ocean-steamship terminals. This property is most advantageously located for such purposes. It would have complete rail connection with all lines and could be physically improved with piers having ample storage facilities and cargo-handling machinery. The opportunity would be presented whereby the port of New York could be almost indefinitely extended and with advantages, vastly superior to those now existing or obtainable elsewhere.

How Traction Companies Remove Snow

As a result of the severe storms of February, 1920, many electric companies found themselves unprepared to cope with storms of real magnitude. Mr. R. C. Cram, Engineer of the Brooklyn Rapid Transit System, sent out a questionnaire to railway companies to find out how they were prepared to handle storms. Representative replies from the East, Middle West and West are summarized as follows in a recent report of the New York State Bureau of Municipal Information.

Buffalo.—The snow fighting equipment of the International Ry., consists of sweepers, snowplows, and rotaries, and only in case the line becomes blocked and it is impossible to open it up with any other equipment is shoveling resorted to. This company seldom removes any snow from the streets by carting away or otherwise, as an agreement for this work is in effect with the city, and the company is assessed a fixed portion of the cost. The railway company does, however, remove all snow from the tracks, in which work it is unassisted by the city. The snow fighting equipment is placed in operation very quickly after snow begins to fall and before 2 in. has actually accumulated.

Chicago.—Chicago railways have large wing plows propelled by three work cars. The snow fighting equipment of the Chicago surface lines consists of 96 sweepers, 11 power plows, 81 drag plows, 49 wing plows, and 7 large sprinkler cars converted into wing plows. During the heavy snowfall of two years ago the heaviest drifts were successfully cleared from the tracks and from an area wide enough for other traffic outside the tracks by the use of a large wing plow attached to a work car. Sufficient power to operate this equipment against the heavy drifts was derived by coupling three heavily motored and weighted work cars together. A single system was connected between cabs so that all three motormen could simultaneously turn on their controllers. This combination appeared to be capable of moving anything, and it was this equipment which made it possible to cope with the unprecedented snowfall without suspension of service.

The practice in Chicago is to clean not only the 16-ft. area over the track, but also, by means of the various wing plows, to push the snow back toward the curbs in order to clear a roadway for trucks and automobiles. This is the only way such vehicles can be persuaded to stay off the tracks. The organization to handle this work is so perfected that upon occasion an army of employes can be called from their homes and put into action in less than an hour's time. Each man knows by prearranged plan just where he is to report and what he is to do if he is called and given the command "snow." The men are fed on the job by the company, so that there is no stopping of the snow fighting work through desertion in search of food and warmth.

A liberal use of salt at all switches and special work locations at the beginning of a storm is considered one of the secrets of keeping the cars moving. A very close contact with the Weather Department is another, serving as it does as a means of anticipating what preparations may be necessary.

Denver.—In Denver in addition to the usual complement of snow plows and sweepers the Denver Tramway Co. uses work cars and autos to carry trackmen to salt the switches, and if the storm is so severe that operation has to cease, work cars and flat-cars are used upon which to load the snow, for removal from the streets. Wing boards are used on flat-cars to push the snow farther away from the track.

When the snow is removed from the streets by flat-cars, the special mechanical pusher, built by the company and described in the issue of the Electric Railway Journal for May 10, 1919, page 924, is used. A few years ago, at the time of a heavy snowfall, three men with this pusher were able to perform the work which otherwise would have required a gang of 15 shovelers. Flat-cars containing from 10 to 14 cu. yd. of snow were loaded at an average rate of 6 minutes per car. The pusher running day and night at a cost of $9 per shift for labor was able to unload more snow than was handled off flat-cars by the city at Sixth Ave. with a cost of more than $80 per shift.

The Denver Tramway Co. has no obligations or arrangements with the city in regard to snow removal, nor is any contract made with outside firms for this work. As soon as the snow begins to fall sweeper crews are ordered to report for duty. The removal work depends upon weather conditions, the hour of day, the kind and amount of snow fall, the time of year and the reports of car crews and inspectors as to whether or not the two-motor car lines are beginning to drag. In the event of a complete tie-up of traffic, due to an abnormal snowfall, the method of procedure is outlined in a standing order covering the work in detail. This standing order is corrected each fall to cover any changes in organization, routes, etc., which seem of value as a result of the experience of the preceding year.

Rochester.—In addition to its snow plows and sweepers, the Rochester Lines of the New York Rys. use two snow-scraper cars and a car with an ice-cutting attachment, which cuts the ice and snow from between the rails. This company has an agreement with the city by which each pays 50 per cent of the cost of removing snow on streets where car tracks are located and each has a definite area to clean. The company removes the snow from the main street intersections in the center of the city and the city removes the snow between these intersections from the curb to curb.

The New York State Rys. do not contract for snow removal, but when necessary, teams are sometimes hired by the day. Sewer manholes are used for the disposal of snow, and this method results in much shorter hauls. In some cases manholes are located at the spot where removal of snow is necessary, thereby decreasing the time of snow removal and reducing the cost of hauling.

The city of Rochester is mapped out in routes for the snow sweepers and plows to follow and these are classified as Routes 1, 2, 3, and so forth. This information is posted in each snow equipment for the information of the trainmen so that each crew will know just what streets to follow and clean, and it, in turn, reports back to the dispatcher's office by telephone at the end of each route or line. A record is kept in the dispatcher's office of each equipment location and of streets cleaned, so that any time during the storm the superintendent and his assistants know where each sweeper and plow is located.

As soon as the equipment is called out, this depending on the density of fall, the location (city, suburban and interurban lines) and what amount of snow is previously on the ground, salters and switch cleaners are dispatched to the main sections of the city, while two trucks are loaded with salt and men are sent to the outskirts to clean and salt the switches. Each truck has its own route to cover. About 20 salt boxes are distributed at principal locations about the city where there is a large amount of special work. The railway company has a private telephone dispatching system operated from a central office in the main office building with a telephone at the end of each car line and at other principal locations. This has proved invaluable in carrying out the snow-fighting program.

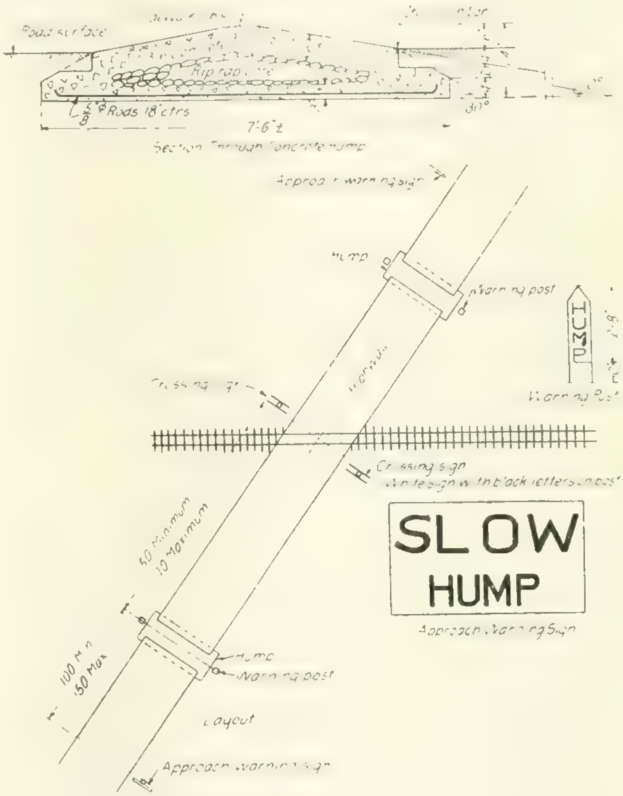
Revising Specifications for Telephone Poles.—At the request of the overhead systems committee of the National Electric Light Association the Forest Products Laboratory is collecting data on the taper and strength of various pole species, including southern yellow pine, chestnut, western red cedar and northern white cedar, in order to check up, or, if need be, revise their standard specifications for poles. Data are also being collected on the efficiency of various treatments commonly used for poles. These data are based on the results of service tests by the Forest Products Laboratory that have extended over a period of approximately 14 years.

51 Per Cent of People of U. S. Live in Cities.—The urban population of the United States, or people living in places of 2,500 or more, is 54,318,032, or 51.4 per cent of the country's total population, and the number of people living in rural territory is 51,390,739, the census bureau announced last week. In 1910 the urban population represented 45.8 per cent.

Protection of Grade Crossings by Humps

At a meeting of the American Association of Highway Officials in Washington on Dec. 16, 1920, Mr. Hunter McDonald, Chief Engineer of the N. C. & St. L. Ry., read a paper on the above subject, abstracts from which we give below, taken from the Railway Age.

"Watchmen, wigwag signals, alarm bells, and even safety gates are often ineffective in preventing men from recklessly sacrificing or jeopardizing their own lives and those of their children and friends by what is often nothing less than criminal carelessness. We have had instances where cars have collided with coaches of the train after the engine and several cars have already passed over the crossing. We recognize that separation of grades is the only absolute remedy, but this is a slow, tedious and expensive process, involving always the question of the equitable distribution of the costs of the work and the raising of the necessary funds. Whatever funds the railroads may have at their command in the early future are already badly needed to place and keep their properties in condition to move their traffic safely and promptly.



Section and Plan for Hump at Grade Crossing.

"Electric appliances, such as gongs and wigwags, when out of order are a decided menace at that very moment, inviting the driver to cross in fancied security, although a train may at that very moment be approaching. Any small boy with a piece of wire on dragging parts of equipment can short-circuit the apparatus and give a false clear signal. It is almost impossible to keep such apparatus always in working order, and, even when working, their warnings are often disregarded.

"For a number of years I have been observing the operation of so-called 'Humps,' which have been installed at grade crossings on many of the highways and on the speedway of the parks in the city of Memphis. The secretary of the Park Commission of Memphis, under whose direction the humps have been installed and operated for eight years past, recently wrote our general counsel that no crossing accident had taken place since they were erected. He states that in one instance the driver of a machine running at a speed of about 25 miles an hour, was thrown out of the car and his arm broken. Suit was brought against the city, but the city won on the ground that a warning sign had been placed at a sufficient distance in advance of the hump to enable the driver to slow down.

We believe, that pending the consummation of the ideal grade separation, a forceful speed deterrent is absolutely essential, and that persuasive methods are of no avail. No law limiting the privileges of the individual can be effective unless applied by force. We are convinced that the hump affords the least oppressive means of applying the force necessary to secure the proper reduction of speed and necessary caution at grade crossings."

The general counsel of the N. C. & St. L. Ry. has prepared a law which it is proposed to have introduced into the Tennessee legislature, providing for humps or other speed restriction devices under the direction of the State Highway Commission, on all grade crossings of railroads within the state not already adequately protected.

The proposed bill provides for a hump in the roadway, on each side of the railroad track; to be made sufficiently high and abrupt to compel a reduction of speed by reckless drivers. It stipulates that within 90 days from its passage the State Highway Commission and other state and county officers, constructing new roads or maintaining existing roads, shall construct at each crossing, within 100 ft. and not less than 50 ft. of the center of the railroad, and on each side, a hump, extending entirely across the highway. The hump is to be 7 ft. 6 in. wide at its base and sloping 10° on each side, meeting in a rounded apex. The toe of the hump must be not less than 6 in. thick and its total thickness must be not less than 1 ft. 4 in. at the center. The proposed law would not apply to crossings in cities or towns.

The bill requires also the erection of signs, from 100 ft. to 150 ft. from the hump, bearing the words "Slow—Hump." The failure of the state officers to comply with the law shall be deemed a misdemeanor and subject to $25 fine, or imprisonment from five to ten days. The railroads would be required to pay one-half the expense of the humps.

Methods of Splicing Piles

In an informal discussion last fall before the Boston Society of Civil Engineers, much valuable information on pile driving practices was brought out. James R. Rollins of Holbrook, Cabot & Rollins, stated that some engineers splice piles by driving the first length, sawing it off, putting a 1½-in. dowel 18 in. long, 9 in. into each length, then putting a splice pipe about 24 in. long over the joint, driving the top section of the pile into the splice. Another way is to use four pieces of lagging 4 in. by 6 in., 15 ft. long, bolted through the piles at joint. When piles drive easy, much increased holding power can be obtained by lagging the piles as just described. This method is used extensively in pier construction in New York Harbor.

Mr. Frank W. Hodgdon, Engineer Massachusetts Commission on Waterways and Public Lands, mentioned where the contractor used the longest piles available and where they apparently went down full depth, but in a material so soft that the engineers were practically sure they would settle when loaded. Accordingly a 6-in. square timber about 20 ft. long was put on the end of a 60-ft. pile; strips 4 in. by 6 in., 20 ft. long were bolted on four sides of the piles. All this lagging, bolts and all, was driven down below the bottom of the dock, so that the whole thing was buried in the supporting earth. They were held together thoroughly.

Special Features at Chicago Good Roads Show.—An interesting feature of the 12th National Good Roads Show which will be held Feb. 9-12 at the Coliseum, Chicago, will be a demonstration by the Division of Tests, U. S. Bureau of Public Roads, in the conduct of the impact tests that the Bureau is using to determine the ability of different soils to sustain roads and to measure the amount of wear caused by heavy traffic. Actual subgrade investigations also will be conducted at the show to demonstrate how the movement of water in different soils can be controlled and road failures reduced. It is expected that this road show will surpass in the number and variety of its exhibits any of the previous shows held by the association. The exhibits will include the various kinds of machinery, appliances and transportation equipment, as well as the materials and methods used in highway construction and maintenance.

New Specifications for Stone Ballast

At the 1920 convention of the American Railway Engineering Association the Committee on Ballast presented in tentative form specifications for stone ballast which were referred back with instructions to put them in final form for adoption. In a recent bulletin of the Association the committee has completed this specification ready for presentation at the 1921 annual meeting in March. A few of the more important items in the specifications follow.

Tests—Weight.—Not less than ½ cu. ft. of the stone accurately measured, and dried for not less than 12 hours in dry air at a temperature of between 125 and 140° F. shall be weighed. A high quality stone is considered to be one weighing 168 lb. per cubic foot.

Strength.—Two-inch cubes of the stone shall be sawed to reasonably accurate dimensions and the top and bottom faces made accurately parallel. For the primary tests, the test specimens shall be dried for two hours in dry air at a temperature of between 120 and 140° F. and at the time of the test the temperature of the specimen shall be not less the 50°.

A high quality stone is considered as testing 10,000 lb. per square inch.

Solubility.—One-fourth cubic foot of the rock shall be crushed and thoroughly washed. The particles shall then be placed in a glass vessel and covered with clear water. The vessel shall be thoroughly shaken for five-minute periods at 12-hour intervals for 48 hours. If any discoloration of the water occurs, the rock shall be deemed soluble and undesirable for use as ballast.

Wear or Durability—(Test No. 1).—One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 in., and exposed to a dry heat of from 125 to 140° F. for a period of two hours. After the dried stone is carefully weighed it shall be given 10,000 revolutions in a tumbler approximately 4 ft. in diameter, of not less than two cubic yards capacity, and operating at 25 revolutions per minute.

The sample shall then be passed over a screen of the minimum dimension provided for sizing the ballast, again washed and dried in the same manner as before the test, and again carefully weighed.

Test No. 2 (Quick Weathering Test).—One-half cubic yard of stone shall be dried and weighed as for Test No. 1. It shall then be immersed in water for six hours and then while still wet, be placed in a refrigerating plant and subjected to a temperature of approximately zero F. for two hours. It shall then be removed and the temperature gradually raised in two hours to 100° and that heat continued for two hours, when it shall be immersed as before and again subjected to approximately zero temperature.

The freezing and thawing shall be repeated to a total of ten exposures. If any tendency to disintegrate is observable the stone should be considered unsuitable for ballast.

A high quality stone for ballast will not show a decrease in fragments which will pass the minimum sizing screen of more than 4 per cent.

Absorption.—One-half cubic yard of washed stone, which will pass through the maximum and be retained on the minimum screen, shall be spread over a wire mesh or iron surface to a depth of not more than 3 in., and exposed to a dry heat of from 125 to 140° F. for a period of 6 hours. After the dried stone is carefully weighed it shall be submerged in clean water for a period of 96 hours. It shall then be removed from water and exposed to a normal air in the shade and at a temperature between 40 and 80°, and allowed to drip for 30 minutes, when it shall again be weighed and the difference in weight shall be used to determine the rate of absorption.

A high quality stone for ballast will have an absorption of not more than 0.50 lb. per cubic foot.

Cementing Quality.—A 5-lb. sample of the rock thoroughly washed and dried shall be crushed until it will pass through a screen of one-fourth inch mesh. This material shall be placed in a ball mill which contains two steel shot weighing 20 lb. each, and the mill revolved at the rate of 30 revolutions per minute, until it has made 2,000 revolutions for each pond of sample in the mill.

Sufficient clean water shall be added to make a consistent mortar, which shall then be moulded into one-inch cubical briquettes, formed under 10 lb. pressure. All of the briquettes shall then be allowed to dry 20 hours in air, when one-third of them shall be tested for compressive strength.

One-third shall be kept for four hours in a steam bath, and the remainder shall be immersed for four hours in clean water at a temperature between 50 and 60° F. and then tested for compressive strength.

If in any of these tests a compressive strength greater than .... lb. per square inch is developed the material shall be deemed unsuitable for ballast.

Of the stone available, that from which the briquettes show the minimum strength should be used; a high quality stone will show not to exceed 4 lb. per square inch.

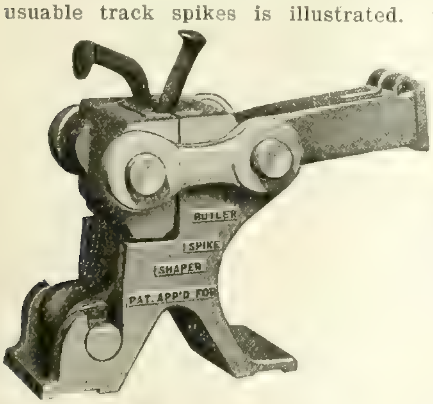
Requirements—Breaking.—Stone for ballast shall be broken into fragments which range with fair uniformitty between the size which will in any position pass through a 2½-in. ring and the size which will not pass through a ½-in. ring.

Test for Size (Maximum).—A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars and placed in or on a screen having round holes 2¾ in. in diameter. If a thorough agitation of the screen fails to pass through the screen 95 per cent of the fragments, as determined by weight, the output from the plant shall be rejected until the fault has been corrected.

Minimum.—A sample weighing not less than 150 lb. shall be taken from the ballast as loaded in the cars; weighed carefully and placed in or on a suitable screen having round holes ½ in. in diameter. The screen shall then be agitated until all fragments which will pass through the screen have been eliminated. The fragments retained in the screen shall then be weighed and if the weight is less than 95 per cent of the original weight of the sample the output of the plant shall be rejected until the fault is corrected.

Handling.—Broken stone for ballast must be delivered from the screens directly to the cars or to clean bins provided for the storage of the output of the crusher. Ballast must be loaded into cars which are in good order and tight enough to prevent leakage and waste of material and are clean and free from stand, dirt, rubbish or any other substance which would foul or damage the ballast material.

A Machine for Straightening Bent Track Spikes



Butler Spike Shaper.

A machine developed for the purpose of reclaiming bent usuable track spikes is illustrated. The machine weighs about 70 lb., is made of high grade electric steel castings, heat treated, and all wearing parts are case hardened. The spikes are squeeged, thereby eliminating excessive wear in the grooves. The grooves are commonly made for two sizes of spikes: 9/16 by 5½ and ⅝ by 6, but the manufacturers will furnish them for any size required. It is claimed that the machine will straighten a spike that is bent and twisted at nearly right angles. The machine is known as the Butler Spike Shaper. It is manufactured by the Werner Machine Co., West Allis, Wis.

Town to Run Electric Railway.—Citizens of the town of Hampton, N. H., have voted to purchase the Exeter, Hampton & Amesbury Street Railway, at a cost not to exceed $80,000, with the understanding that if the road failed to pay expenses the town of Exeter would make an annual contribution of $2,500 for a term of five years. The road, which is 20 miles in length, was built in 1897.

Aberthaw Construction Co's. Instructions for Its Field Men

In response to many requests for literature and instructions for the field force, the Associated General Contractors is investigating the practice of contractors in regard to supplying job literature. Inquiry has developed the fact that contractors are not only awake to the possibilities but also that certain companies are supplying their field men with valuable instructions. One of these sets of instructions, that of the Aberthaw Construction Co., Boston, Mass., is reviewed at some length in the December Bulletin of the association. The review follows in full.

Contractors who envy the manufacturer who can set his mill running, and then go away and cut coupons, will want to know more about the Book of Aberthaw. While it would be impossible entirely to eliminate the process of "taking it up with the office" in construction, the possible saving in correspondence, delays, and executive time and patience which might be effected on any job is shown in the Aberthaw Bible. The secret of this method, which has proved successful, is as old as science. It involves four steps: (1) the collection of ideas, policies, and methods which have proved of value, (2) their orderly classification and analysis, (3) the adoption of general rules and policies therefrom, and (4) a permanent record of the results easily accessible.

The Aberthaw Construction Co. of Boston furnishes each of its superintendents with a loose-leaf manual, the subject matter of which deals with company policies, methods, and the details of carrying out a building contract. All practices relating to forms, reports, accounting and office detail are covered, and policies affecting the more intangible problems such as relations with the owner, the architect, the engineer, the sub-contractor and company employes, are carefully set forth. It is intended not only to standardize the work of different contracts and thus effect substantial economies for both owner and contractor, but also to give instructions and information concerning the hundred and one details which frequently are overlooked, and which mean much for smooth sailing. Unlike its great namesake, the Aberthaw Bible exists to be added to and revised continually, and any new policy or practice which has proved successful is ultimately given its proper place in this company book of books.

Laying Out the Work.—In spite of the utmost care in laying out new work the superintendents often omit important details which may handicap them until the end of the job. To prevent such occurrences, the Aberthaw book supplies detailed instructions for use in organizing the work.

Certain transactions are negotiated by the Boston office. These are explicitly stated to avoid confusion; also certain materials and supplies are purchased by the home office or carried in the company yard and concerning these, full information is given. Other questions pertaining to the construction which must be considered at the outset are answered in the company's standard drawings. These drawings, which are reduced in size for use in the manual, have been adopted after thorough trial. They save a great amount of time on the job and eliminate the possibility of poorly designed structures. By the use of such drawings less claim is made upon the superintendent's time, which may then be more fully devoted to managing the work and improving methods. About fifty of these are supplied, among which are included the following:

- Temporary buildings
- Hoisting towers
- Derricks
- Scaffolds
- Centering
- Runways
- Brick elevators
- Temporary stairways
- Track lay-outs.

Insuring Efficient Methods.—The methods used by the Aberthaw Co. on building operations have become sufficiently standardized to be included in the manual of construction. They are explained in such detail that any serious error in the method employed is practically impossible. The following paragraph, for example, is an excerpt pertaining to concreting under water:

> Do not place concrete under water if this can be avoided. If unavoidable, pour concrete through a chute so that it reaches the bottom without passing through open water. Avoid all movement of water where concrete is being deposited. Equalize the pressure immediately by filling to the natural grade of the water any por-

tion of the work completed and do not again pump out until the concrete is thoroughly set. Do not place concrete in water contaminated with sewerage, acid, mud, or other impurities.

Winter concreting may be safely carried on by following the directions pertaining to aggregate thawing, placing, heating and protecting work. In fact, a good method of handling nearly every piece of the work from sub-surface to interior finish has been supplied for the superintendent's reference.

Maintaining Cordial Relations with Employes.—The Aberthaw Co. has formulated a definite labor policy based upon thorough investigation and each member of the field organization is kept informed through the Bible of the principles governing the treatment of workmen. The following quotation from the manual is illustrative of these:

> The officials of the Aberthaw Company are fully alive to the necessity of having the good will and co-operation of every member of the organization. It is hoped that all will feel free to talk over matters with the company officials at any time, whether it be of the nature of a suggestion for improved methods, criticism of policy or some grievance which might be eliminated. It is the intention of the company to treat all with the utmost fairness and to maintain a keen regard for the rights of its employees. The Company is making every effort to give its men:
>
> 1. As steady employment as possible.
> 2. Proper compensation in proportion to their value.
> 3. Help in getting them located where they will be the most effective.
> 4. Instructions to improve their value.

To carry out the principles stated above and to raise the standard of efficiency of the whole force, a labor department is maintained. An important feature of the labor policy are the Service Book and the Laborer's Record Card, the purpose and value of which are carefully set forth in the superintendent's manual. The first is issued to employes who have given satisfactory service under two or more of the company's superintendents; or, in special cases, upon extended service of unusual satisfaction under one individual. The Record Card is issued to men showing exceptional ability on the work, especially in concreting operation. Holders of cards and books receive preference in employment. Special inducement is offered them to improve their status and remain with the company. A list of the Bookmen is printed in the manual of instructions and also kept in the Boston office, which attends to placing them on other work as desired. Instructions also provide the manner of paying, hiring, changing rate and dismissing employes. Special instructions apply to men engaged in accounting, correspondence and recording.

Standardizing Field Office Work.—Standard practice for handling the field office work, as laid down in the manual saves a large volume of correspondence with the home office, and enables it to compare the progress and cost of different jobs. About 60 forms are provided for the clerical force which tie in with the filing system and final records in such a manner that a detached history of each job is available at the end. The following are a few of these forms:

32. Sub-contractors charges memorandum.
39. Job cash statement.
54-a. Weekly cost summary.
57. Labor cost record.
93. Sand and gravel book.
177. Safety inspector's daily report.
216. Plant and tool record.

By the use of forms pertaining to material work a great volume of detail is eliminated, thus simplifying the work of material accounting. The duties of the material clerk in handling his records are explained in such a manner that he need spend little time wondering how to handle some matter or in "taking it up with the office." The amount of writing is reduced to a minimum, and by use of these forms, office men may concentrate their efforts upon accuracy.

Handling Equipment.—As questions pertaining to shipping often create trouble, directions are given for shipping by freight and express, and for keeping the car records. The shipping of plant between jobs and the home yard receives special attention. Equipment is also standardized by the company; and the machines and accessories common to building operation which are maintained in the home-yard ready for transit to any job, are listed in the manual. Equipment accounting, renting and repairing are handled in accordance with a fixed policy which is fully explained and as ready accessible to the newest as to the oldest superintendent. All plant is divided into classes according to life for determining the amount of depreciation. From the information given on this subject, the rental charge for tools and equipment may be found. The care of equipment is explained and a definite system of accounting is fixed for distributing the expense, which ties in with the whole system of accounting and time-keeping.

Checking Expenses Daily.—To assure an accurate distribution of time to the respective work units, the duties and the system of handling pay-rolls, overtime, etc., are fully explained; and an index of the Mnemonic system of cost distribution used in segregating expense, is contained in the manual. As a result distribution is made daily as the work proceeds and constant comparison with the Bogey Score or estimate analysis is thus possible. Such comparison gives an effective means of controlling costs.

Reducing Accidents.—Closely connected with the work of reducing costs is accident prevention. Instructions for the superintendent, for the company accident inspector who makes the daily report of the job, and for the foreman to follow in guarding against accident, are given, and the safety appliances which must be installed on each job are listed.

A special list of dynamite "Dont's" for foremen is illustrative of the care with which each subject is covered.

Other questions upon which a superintendent may need advice are called to attention and discussed in the instructions. Among these are such matters as the following:

Handling extras, company signs, legal advice, shipping and routing, sanitation, expediting, handling, sub-contracts, closing the work, and turning in the records.

Standards Established.—The Aberthaw Bible has been the means not only of standardizing work, but also of raising the efficiency and esprit de corps of the whole field organization. Far from killing individual initiative, it has relieved the force of much routine. The company standards thus established have given the firm an individuality among both its employes and its clients, which goes far to remove the curse of corporate organization.

Army Construction Division Association to Have Reunion

The annual reunion of those who were identified with the Construction Division of the Army during the war will be held at the Morrison Hotel, Chicago, on Feb. 25 and 26. The afternoon of the first day and the morning and afternoon of the second day will be devoted to business sessions and the annual banquet will be held on the evening of Feb. 26. The membership of the Construction Division Association consists of those who served in the Construction Division of the Army during the war, either in uniform or as civilians. The officers are: President, Colonel Clark C. Wright, of George C. Nimmons & Co., 122 S. Michigan Ave., Chicago, Ill.; Vice-President, Colonel J. N. Willcutt, of R. D. Willcutt & Sons Co., Boston, Mass.; Secretary, Major George Gibbs, Jr., Washington, D. C.; Assistant Secretary, William Kennedy, office of Colonel Evan Shelby, 63 Wall St., New York City; and Treasurer, Major A. C. King, 8 S. Dearborn St., Chicago, Ill. Colonel E. C. Stockdale, of Page & Hill, 19 S. La Salle St., Chicago, is chairman of the Entertainment Committee.

Novel Method of Tunnel Driving.—A novel method of driving a tunnel heading, practiced in the Nordhausen mining district of Germany, is described as follows in a recent issue of Compressed Air Magazine: Instead of following the usual practice of driving two or three shot holes inclined toward each other in the center to unkey the surface of the work, the holes are bored quite close together parallel with the axis of the drift and locally known as "canon-shots." These are arranged and fired to make a hole of no great diameter in the center of the face by crushing the rock. Then a ring of shot-holes is bored around this central opening and fired. This removes a considerable mass of rock, thereby greatly enlarging the central opening. Another ring of holes, more widely spaced, clears the face. The novelty consists in the closely situated central crushing holes. Being so near together, it is not necessary to have a primer and fuse in each. The concussion of one shot is sufficient to fire the rest. The resulting face of the heading is left flatter and in better condition for starting the next drive. The success of this method must evidently depend largely upon the character of the rock.

A Modern Method of Laying New Rail

The Lehigh Valley R. R. has developed a rail laying method, in which has been incorporated the use of such labor saving equipment as locomotive cranes, air compresors and drills, etc., which has resulted in increased output and reduced costs. With this method daily averages are being made of from 80 to 110 rail length per hour, all completely bolted, spiked, etc., and ready for service, while in special instances as many as 159 rails have been laid in one hour. The method is described in the Railway Age, from which the matter in this article is taken.

In conducting this work the necessary labor has been secured by assembling the section forces employed in the locality where the rail is to be laid. The work is then so planned as to be carried on in a series of progressive stages or steps, such as, pulling spikes, throwing out old rail, etc., each step being assigned to a required number of men. In practically all but a few cases the individual gangs or sub-divisions of the forces are composed of section gangs complete with their foremen or multiples thereof. The foremen work with their men as well as supervise them. This feature in itself has been found to speed up the work materially.

With the forces and equipment assembled and all assignments understood the track upon which rail is to be laid is taken over completely and operations commenced. During the period of laying the remaining track is operated as a single track section. Through the close co-operation of the operating department little delay has been caused by the adoption of this method, even under comparatively heavy traffic. It is a question whether or not the delays caused by laying rail under traffic do not equal or exceed the delays when the track is given over entirely.

At stated before, the method is based on progressive steps with all new materials distributed previously along the section to be laid. The old track is not disturbed under any circumstances until the time when it is taken over. The sequence of the various stages is in general as follows: Joints are broken every 10 rail lengths, spikes pulled, one rail thrown out, old tie plates removed, creosoted wood plugs placed in old spike holes, ties adzed, new tie plates placed, new rail laid with locomotive crane, rail center spiked and gaged, joints placed and bolted, holes drilled and bond wires installed, track gaged and full spiked, signals connected up and work generally finished up.

Where one crane is used a force of about 200 men are required to keep the crane working to its capacity and the work proceeds one rail at a time, the crane being moved back to the point of starting at the completion of the laying of the first line of rail and starting on the second rail. With two cranes a duplicate organization follows the first crane preparing the other rail for the second crane, both of which are followed by a finishing gang of about double the size.

Rail bonding is carried on by means of portable units of air compressors and their drills. One compressor generally handles four drills requiring a crew of six men. The saving of labor in this item has been very marked and a much greater output has been obtained in addition to increasing the life of the drills from five to eight times. In connection with this class of equipment several pneumatic wrenches were tried out recently for the purpose of running up the nuts on the track bolts. The average time consumed for running up one 6-bolt splice and moving to the next was about 30 seconds.

Figuring on a one-crane basis, as any multiple up to four can be used efficiently on one set of tracks provided there are sufficient men available, the following is a typical organization in detail: The men comprising this organization are listed in the exact sequence under which they pass over the track.

A TYPICAL ONE-CRANE ORGANIZATION
ADVANCE WORK.

3 men removing every tenth joint on the old rail.
24 men pulling spikes. This includes 2 foremen.
14 men swinging out old rail. Two foremen with section gangs.
3 men throwing out old tie plate.
3 men placing creosoted tie plugs in spike holes.
2 men driving creosoted tie plugs in spike holes
12 men adzing ties. One section foreman included.
2 men sweeping off ties after adzing.
5 men placing new tie plates. One foreman included.

This covers the preparatory work for the crane, which has the following organization:

4 men on rail, two on each end to steady and guide it into place.
1 man on crane hook. The foreman in charge of crane forces.
1 man on expansion template.
2 men driving spikes on inside of new rail.
2 men driving spikes on outside of rail after laid.
1 man with lining bar to bar rail to place as laid.
2 men operating crane. The operator and fireman.

The locomotive crane was followed by the following gang:

1 man adzing joint ties for a 1 to 20 cant.
10 men placing new joints. Two foremen included.
5 men removing rail anchors from old rail.
1 man placing insulated joints.
12 men gaging new rail.
34 men full spiking.
30 men bolting up joints.

This was followed by the bonding layout and the finishing gangs:

4 men operating air drills.
2 men operating motor cars and distributing bond wires.
1 man operating air compressor.
2 men bonding new rail.
5 men clearing out for rail anchors. One foreman included.
5 men placing new rail anchors. One foreman included.
2 men operating motor cars, two trailers with extra tools, etc.
3 men checking up on tie plates, spiking and joints, etc. One foreman included.
3 men carrying drinking water.
1 man charging wire at signal connections.
1 man soldering signal connections.

With the experimental introduction of the pneumatic wrenches the organization was changed slightly from that shown above, the 30 men assigned to bolting being removed and the following substituted for them:

2 men on pneumatic wrenches.
1 man tapping joints into place.
1 man on air hose
1 man operating motor car.
1 man operating air compressor.

In the particular instance mentioned above a stretch of track between two switches located nearly 2½ miles apart was laid with 136-lb. rail in a total elapsed time of 7 hours 10 minutes, or at the rate of 107 rail lengths per hour for a total of 770 rails. The force shown totals up to 205 men in the first case and 180 men with the introduction of the wrenches.

Operations of Sea-Going Hopper Dredges in New York Harbor

In a discussion of Mr. A. W. Robinson's paper,* "Larger Ships, Better Harbors and Better Dredges," presented Oct. 8 before the American Society of Civil Engineers, Col. Edward Burr, Corps of Engineers, U. S. Army, gave some interesting information on the operation of sea-going hopper dredges in New York Harbor. Ambrose Channel, with a depth of 40 ft., and a width of 2,000 ft., was excavated with sea-going dredges of the hopper type; 66,000,000 cu. yd. were removed at an average cost of 6.12 ct. per cubic yard, the distance to the dump being on the average 10 miles. Of this quantity, 47,428,000 cu. yd. were removed through the operation by the United States, on force account, of four dredges built for this work, the average cost being 5.36 ct. per cubic yard, including all expenses, but with credit for the remaining value of the dredges on the completion of the work. The material was sand varying from fine to coarse, with some small gravel and varying quantities of mud up to 20 per cent. A large number of dumps of stone were encountered and increased the cost of the work.

When Ambrose Channel was completed, there remained on hand two of these dredges for which there was then no employment for ocean-bar dredging, and they have since been used on the improvement of the interior channels of the port with marked success in two important respects, economy and non-obstructiveness to traffic. Five years' operation in the main channels of the inner harbor, all the year round on a 24 hour basis, have resulted in no complaints from navigators and few accidents, none of which has been serious.

Although these dredges were designed to handle the sand of the ocean bar, they are used with marked economic success in removing mud, such as the Hudson River silt, in the inner harbor, and have been successfully used on clay or gravel and cobbles. The Raritan (bin capacity 2,884 cu. yd.) in the course of about 6 years dredged 5,565 loads from Ambrose Channel at rates varying between 1.4 and 10.1 cu. yd. per 20-in. pump per minute of pumping time, and averaged 6.04 cu. yd. per pump per minute of pumping time (362.4 cu. yd. per hour per pump and 725 cu. yd. per hour for the dredge) for the entire job under all the varying conditions of dredging, weather, and material, including some dredging at anchor, all of which militate against the dredge. In Hudson River silt the Raritan has averaged over 600 cu. yd. per pumping hour for considerable periods. These figures are "bin measurement," and neglect the material dredged and carried overboard in the overflow which, although small in sand or other heavy material, is relatively large in light material, and should be credited to the dredging equipment considered merely as an excavator.

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*See Engineering and Contracting, Nov. 17, 1920.

As transportation units when the spoil must be deposited at a distance they are also most efficient. Notwithstanding the relatively high overhead material, and labor costs resulting from greater first cost and operating cost as compared with the customary unit composed of a tug and one or more dump scows, New York transportation or disposal cost from points in the Upper Harbor for hopper dredges is less than 50 per cent of the cost of scow disposal. This results from sea-worthiness and greater speed (9 to 10 knots) and consequent practical independence of tide and weather conditions. Figures of actual cost are reliable only for the period covered by them, on account of constantly and widely varying prices of labor and material, particularly coal, but the disposal costs for two hopper dredges averaged about 0.4 ct. per cubic yard mile in 1919.

New Signal Lamp for Triangulation Work

For triangulation in which the lines are shorter than the average length the U. S. Coast and Geodetic Survey has found need for a signal lamp requiring less current and therefore less expense for dry cells, than the present high-power lamp designed for lines up to 180 miles.

This need, according to a bulletin of the Survey, is thought to have been filled by the design and construction in the instrument section of a new signal lamp, made up from a Ford automobile headlight with 7-in. reflector, mounted in an open frame of wood, so as to permit of adjustment in altitude and azimuth, provided with a sighting tube, a 11-ohm rheostat, and a switch for continuous lighting, as well as Morse coding. The outside dimensions are: 10½ in. wide, 11 in. high, 6½ in. deep. The weight is 7¼ lb.

An appeal to the lamp engineer for a bulb carrying a filament of the same diameter and length as those employed in pocket flashlights, but wound with special view to the projection of a beam with smallest possible angle, resulted in the production of a new bulb in which the filament is coiled into a helix 0.05 inch long and 0.04 inch diameter. The bulb is of the G-12 size and is gas filled. It is rated 3.7 volts and 0.6 ampere.

The apparent beam candlepower at distance of 100 ft. of this new lamp was determined by the Bureau of Standards as follows:

Volts	Ampere	Candlepower
4.2	0.57	26,000
4.6	.61	45,000
5.4	.66	74,000

It is thought that about 10 or 15 dry cells of the ordinary 6-in. size will be ample for one triangulation station.

Method of Loading "Gopher Holes"

"Gopher holes" at one of the large open pit iron mines in Northern Minnesota, are loaded by pouring the black powder directly from the can into a small wooden launder, which is inclined so that the powder will run into the hole. The launder is of sufficient length to reach the end of the hole, so that the explosive may be poured in without leaving a train of powder, and the inner portion of the hole may be filled first. The "gopher holes," states the Engineering and Mining Journal, from which this note is taken, are usually 15 in. in diameter and sometimes as much as 25 ft. long. They are dug into the stripping banks by means of long-handled shovels and are usually "sprung" or chambered before the charge of powder is placed. The springing consists of a preliminary blasting with dynamite so that the "gopher hole" is enlarged inside. From 5 to 10 kegs (25 lb.) of black powder are used for the final blasting. This practice of "gopher holing" is used to bring down high banks in the open pits where it is desired to entirely remove the overburden or to break down the bank which might be a menace to the men working below.

A covered box, provided with a hopper bottom and fastened to one end of a closed launder, is sometimes used for the same purpose. The powder is poured directly into the hopper, the cover shut, and a plug closing the bottom of the hopper is removed by a cord through the cover, permitting the powder to run out. The launder is then given an oscillating motion, so that the powder will run into the hole. This contrivance is safer than the launder previously described, as it is possible to protect the powder from the danger of flying sparks.

The Sorry Plight of the Patent Office*

Various engineering societies have recently been giving support to an effort to relieve the desperate condition of the U. S. Patent Office by passing the Nolan Patent Office Bill, H. R. 11984.

The purpose of this bill is to increase the examining and clerical forces of the Patent Office and to raise their salaries so as to give that office a sufficient force and at salaries that will attract and hold competent men to enable it to make its examinations with that reasonable promptness which is necessary to make it worth while applying for them and with such thoroughness as to reduce the percentage of errors to as low a limit as sufficient time for the work and proper qualifications can possibly effect.

The bill has been passed by the House of Representatives, without amendment and by a large majority.

A hearing on the bill was held by the Patent Committee of the Senate, but in order to remove objection to unanimous consent to a special hearing by the Senate, before adjournment of the session, the Patent Committee of the Senate consented to amendments so seriously reducing the force and salaries of the bill as passed by the House of Representatives as to reduce the examining and clerical forces below the numbers now actually employed in the Patent Office. The increases of the salaries provided in the bill were also cut down to where they are seriously inadequate to attract or hold a sufficient number of qualified men to enable the Patent Office to do its work. The steady exodus of examiners from the Patent Office, which has been going on for some time, has not been stayed at all by the passage of the bill by the Senate.

The bill has been referred to a conference committee of the Senate and House.

On Oct. 21, 1920, Engineering Council unanimously passed some resolutions with reference to this important matter, which follows:

Whereas, The United States Patent Office is vitally important to our industries, to induce the production of scientific and technical improvements and to enable our industries to keep abreast of those of other countries; and

Whereas, The volume of work of the Patent Office for many years has increased much more rapidly than its examining and clerical forces have been increased, and the work in the past fiscal year has increased 36 per cent above the work of the previous year; and

Whereas, The salaries of examiners, except for a war bonus, have only been increased 10 per cent in 70 years and are so low that resignations of examiners are constantly occurring in a steady stream, averaging 25 per cent per annum, and resulting in such frequent changes that much inefficiency unavoidably results therefrom, even where examiners are qualified for the work, and many men are necessarily employed as examiners who cannot pass the examination required to qualify for their positions; and the salaries of the clerical forces are considerably below the average of salaries for corresponding work in the governmental departments generally; and

Whereas, As a result of such situation, the Patent Office is at such a great disadvantage that it unavoidably grants an undue proportion of defective patents, resulting in heavy losses both to the inventors and the public, due to useless development and unnecessary litigation, and the Patent Office is so far behind in its work that the value of many transactions with it is greatly reduced and in some instances destroyed by the delay; and

Whereas, As a partial remedy for such situation Nolan Bill H. R. 11984 was introduced into Congress providing for an increase in the examining corps of the Patent Office of but 5.8 per cent and an increase in the clerical force of but 3.9 per cent, and providing increases in the salary for the position of primary examiners from $2,700 to $3,900 and of assistant examiners in proportion, and providing increases in the salaries of the clerical force only to bring them up approximately to the average corresponding salaries of other Governmental Departments and Bureaus, and as the cost of the increased salaries and force of the said Nolan bill was more than met by an increase in the fees for patents provided therein; and

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*From a bulletin of the American Railway Engineering Association.

Whereas, The United States Senate so amended the said Nolan bill that instead of increasing it decreases the examining corps by 15.7 per cent and reduces the clerical force by about 1 per cent below the present insufficient numbers of said examining corps and clerical force actually employed in the Patent Office, as well as reduces the salaries, both of the examining and the clerical forces, so that the total present payroll is reduced 5.9 per cent, notwithstanding that the increase in the fees for patents which were made to provide funds for the increased force and salaries were retained in the bill; and

Whereas, In the opinion of Engineering Council, the general effect of the changes in force and salaries made by the Senate would amount to a catastrophe for the Patent Office; and

Whereas, The salary of $3,900, provided in the bill as it passed the House of Representatives, is low for the position of Principal Examiner when compared with the salaries paid by private corporations and employers for engineers having a similar grade of responsibilities and requirements—that is, engineers required to make and assume responsibility for final decisions in important matters and to have highly technical knowledge—especially as sucn examiners must have both legal and technical knowledge and notwithstanding allowance for the fact that Governmental salaries are not as high as those paid by private interests; and the salaries for other grades of examiners are low in proportion; now, therefore, be it

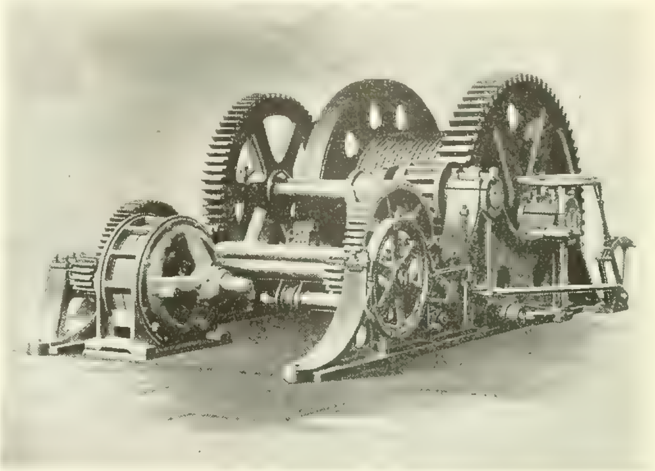
Resolved, That Engineering Council, representing 45,000 engineers, regards it of large importance that the numbers of the examining and clerical forces for the Patent Office and the salaries therefor in Nolan Patent Bill H. R. 11984 be restored to those in the bill as it passed the House of Representatives; that the bill be freed from any riders, such as Secion 9 thereof, which may delay or jeopardize the passage thereof, and that the bill be made a law at the earliest possible moment.

Engineering Council, having on the 21st day of October, 1920, passed a resolution urging the restoration to their original values of the figures for the examining and clerical forces of the Patent Office and the salaries therefor in the Nolan Patent Office Bill H. R. 11984, recommends that the constituent engineering societies which i represents requests their memberships to communicate with their Representatives and Senators in Congress, urging action in accordance with the said resolutions.

As the Patent Office is steadily losing more and more of its competent men and is rapidly getting farther and farther behind in its work, and as to get much farther behind would mean for it practically to cease to function, and as the bill, as amended by the Senate, is wholly inadequate to accomplish its purpose, and would be worse than useless, every effort should be made to induce Congress to restore the figures of the bill to their values as passed by the House of Representatives.

New Electric Barney Hauling Machine

A new type of electric Barney hauling machine is being used by the Boston & Albany R. R. at its Beacon Park plant, Allston, Mass. For coaling locomotives, this railroad has a large coaling plant consisting of a frame building containing large hoppers over which is a standard gage track on which the coal cars are run. This upper track is reached by a long grade of 26.67 per cent. A train load of loaded coal cars is left on one siding and one car is pulled forward into position by a small electric car puller built by the Mead-Morrison Manufacturing Co., East Boston, Mass. When the car reaches its proper position, the small car puller is disconnected and the large machine shown in the upper illustration is started. A "billy-goat" which is of cast iron and which runs on wheels on a narrow gage track, is pulled by a 1½-in. diameter steel cable connected to the hoist drum. This "billy-goat" normally rests in a narrow concrete trench between the rails, and when pulling is started, it butts the rear of the standard coal car. This pushes the car up the long incline until it reaches the top over the hoppers, where it discharges its coal through gates on the bottom of the car. Tracks are on each side of the coaling house so that locomotives can get their coal from chutes which are on each side of the house. After the car is emptied, it is started down the incline and in this case pushes against the "billy-goat." At the bottom of the run the "billy-goat" is allowed to travel at full speed so that it can get away from the car which slows down when leaving the incline and going on to the level track. The "billy-goat" then goes out of sight between the rails and the car takes a flying switch on to a side track used only for empties. When it is considered that the figured rope pull is 60,000 lb., it will be seen that it is quite necessary to have the hoist fitted with suitable automatic devices to prevent the car from starting backwards on the incline should the electric current be cut off for any reason. In the immediate foreground of the upper illustration will be seen the Mead-Morrison patented releasing automatic brakes. This unit is the safety device, which prevents the load from overhauling the machine should the electrical current fail. Its application is stated to be so quick and sure that the load never gains momentum, but is stopped instantly. At the right of the picture will be seen the operating lever, which releases this automatic brake so that the car may be safely lowered back on to the horizontal track.



Upper: New Mead-Morrison Hoist. Lower: Car Puller in Operation.

The hand lever shown at the right is for operating the steel jaw clutch on the main pinion shaft and the hand wheel is for the powerful brakes on the drum flange. The approximate shipping weight of the machine is 30,100 lb.

Drilling Frozen Chunks of Earth with Steam Jet

Stripping at the open pit mines on the Mesaba iron range of Minnesota is carried on during the winter months. In ordinary practice the ground in front of the steam shovel is loosened by means of blasting, and in this procedure holes are first drilled, either by means of jumper drills or steam jets, loaded with dynamite, and then fired. It frequently happens that large mases of earth are overcast by the shovel and occupy positions above the shovel cut, where they are not only a source of danger, but are of such size that they cannot be conveniently handled by the steam-shovel dipper. In this event the chunks are drilled and then blasted. The steam jet, according to the Engineering and Mining Journal, has proved very useful in drilling through frozen chunks. In this work a length of steel pipe is sharpened at one end and the other is placed in a steam hose. Steam is obtained from the steam-shovel boiler, and in some instances several lines of hose are supplied. When the steam is turned on, the operator forces the point of the drill into the frozen ground, turning it as he does so. A steel plate is placed on the pipe in such a manner as to protect the operator tion, the steam or pieces of earth that may be blown out of the drill.

Indiana Road School.—The seventh annual Indiana Road School will be held at Purdue University, Lafayette, Ind., on Jan. 18th, 19th and 20th. The annual meeting of the Indiana County Highway Superintendents' Association and the Indiana Highway Contractors' Association will be held in connection with the school.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

J. W. McMurray traded an apartment house and a farm he had near Kansas City for one of the best farms in Callaway County, Mo. Mack is going to breed fancy cattle as a side issue.

Ira A. Cox, 1210 W. 7th St., Sioux Falls, S. D., has 22 miles of road work in Lyon County, Ia., to sublet. There is some splendid machine work on this job.

The American Locomotive Company of Pittsburgh has purchased 205 acres of ground in Granite City, Ill., where it will erect a plant to cost $15,000,000, according to announcement by the company. The East St. Louis Locomotive and Car Company, which recently bought a 147-acre site south of the free bridge, will erect a plant there to repair locomotives and cars. The company is capitalized at $5,000,000. The location of these two plants in this district is expected to create a railroad equipment center similar to the street car manufacturing center the St. Louis district has included for many years. The strip of land, which was sold through bankers and real estate operators of the tri-cities, extends for a mile in one direction. The Wabash Railroad tracks extend along its western boundary and the tracks of the Terminal Railroad along its eastern edge. Several other trunk lines run through the surrounding territory, most of which terminate in East St. Louis. A large mileage of switching and connecting track will be built near the factory, it is said.

Mulvill Bros. are putting in four sidings for the Chicago & Alton R. R. at Auburn, Ill.

The same company which put through the construction of the electric line from Kansas City to Excelsior Springs and St. Joseph is now working on plans for building a line across Missouri from St. Louis to Kansas City. The new road is to follow an old survey east of Independence via Pink Hill and Mecklin to Higginsville and Marshall, thence to Arrow Rock, where the Missouri River is to be crossed, and it is said that Columbia and Fulton will be on the proposed route. Several days ago a representative of the company was at Odessa interviewing farmers in regard to securing permission to cross their line. It is the plan to run the line as near as possible midway between the Chicago & Alton and the Missouri Pacific. This would leave Odessa about five miles south of the electric line. The new company claims to have plenty of money to build the line and is not asking for any stock subscriptions from persons along the line. It is said that many farmers in the neighborhood of Oak Grove are giving a right-of-way free of charge.

S. Hannefin will finish his work on the Frisco R. R. at Eureka Mo., in a few days. Wants a job for his 12-team outfit.

The entire Antire road, 15 miles in length, from Valley Park to Eureka, Mo., will be resurveyed and relocated preparatory to surfacing it, under an order issued by the County Court at Clayton to Road Engineer Elbring. The court also decided that the connecting road west of Eureka, to Tilenton and Pacific, which with the Antire road forms part of the projected Ozark Trail, should be straightened and leveled. The road is to be widened from 30 to 40 feet. The Rankin estate, through whose property the road runs west of Eureka, has agreed to permit the straightening of the road by a new survey without damages. The Tavern Rock Sand Co. has also given permission to detour the road by its quarry near Pacific to avoid a steep hill over which the road now passes.

I. L. Simmons, La Plata, Mo., has his 10-team outfit idle. Looking around for a new grading job.

Billy Danklif has finished his work on the Northwestern R. R. in Illinois. Is wintering his outfit at Mt. Olive, Ill.

A certificate was granted to the Chicago & Alton R. R. Co. Dec. 29 to construct new yards to cost approximately $1,000,000 in Springfield, Ill. A round house, additional trackage and the possible moving of the C. & A. shops from Bloomington are provided for in the plans. Work will start early next spring.

Frank Palmer has a 10-ton outfit idle at Kimball, Nebr.

[illegible] S. Jones is moving an outfit [illegible] station work on the Texas Pacific R. R. in Louisiana. Jones has several good station outfits idle that he can place on work immediately. Address him care of Koenig Labor Agency, St. Louis, Mo.

The St. Louis Chapter of the American Association of Engineers has appointed a committee to investigate the feasibility of financing and erecting a club to house the chapter rooms and provide living quarters for unmarried members. S. Sammelmann, assistant chief engineer of the Division of Sewers and Paving of the City of St. Louis, has been made chairman of the committee.

Ira J. Printy reports splendid progress with his road work in southern Illinois.

Contractors when in want of labor or work for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo.; 503 Delaware St., Kansas City, Mo., or 1020 Douglas St., Omaha, Nebr.

The St. Louis County Court on Jan. 14 ordered that $280,000 road bonds, of the $3,000,000 issue voted for Feb. 15, 1916, be advertised for sale. This is the second lot of that issue to be placed upon the market, $520,000 having already been sold and 38 roads with bridges and culverts built. The bonds are in denominations [illegible] in 20 years, or whenever the court calls. In the latter case they [illegible] The present market price of St. Louis County road bonds is below 95, the minimum price for which they may be legally sold, and the court has decided to hold private sales if brokers bid under 95.

Personals

F. B. Hayes has been appointed city engineer of Pendleton, Ore.

Charles Hackel has been appointed chief engineer of the Trenton & Mercer County Traction Co. of Trenton, N. J.

Arthur H. Blanchard, Consulting Highway and Transport Engineer, Ann Arbor, Mich., has been retained by the city of Colorado Springs in connection with its $1,200,000 paving program.

Llewellyn N. Edwards has recently assumed the duties of bridge engineer for the Maine Highway Commission, Augusta, Me. Previous to accepting this position he was senior highway bridge engineer, U. S. Bureau of Public Roads, assigned to District No. 6, which embodies the states of Oklahoma, Arkansas, Texas and Louisiana.

C. Duckworth of Salt Lake City, Utah, roadmaster of the Western Pacific R. R. between Gerlach and Elko, Nev., has been appointed engineer of the eastern division of the road, with headquarters at Elko. He succeeds H. C. Maxon, who was killed in a collision of velocipedes on the Western Pacific near Saldura, Utah, November 26.

Charles Scott, supervisor of bridges and buildings on the Buffalo, Rochester & Pittsburgh R. R., with headquarters at East Salamanca, N. Y., has been promoted to acting engineer of masonry with the same headquarters, succeeding George H. Stewart. W. E. Maley has been promoted to acting supervisor of bridges and buildings to succeed Mr. Scott.

Frank A. Burr of Providence, R. I., has been appointed to the faculty of Rhode Island State College to fill the vacancy caused by the absence of Prof. Royal L. Wales, who is now engaged in research work in the Bureau of Standards at Washington. During Prof. Wales' leave of absence, which covers a period of eight months, Prof. Samuel H. Webster has been designated acting dean of engineering.

National Engineering Service Corporation, with principal offices in Kansas City, Mo., and business offices in New York and Chicago, has been engaged to have full charge of all of the engineering and construction of water power Project No. 59, Arizona, Nevada and Hualapai Indian Reservation, consisting of seven power sites in the Colorado River. This is one of the notable water power projects under consideration at the present time. It is expected that active work will be undertaken immediately.

Robert E. Horton, Harry Barker and Robert C. Wheeler have become associated under the firm name of Horton, Barker & Wheeler to continue their consulting engineering practice formerly carried on under the names of Robert E. Horton, Consulting Hydraulic Engineer, Albany, N. Y., and Harry Barker and Robert C. Wheeler, Engineers, New York City. The new firm will have its headquarters in Albany, N. Y., with offices in New York, Harrisburg, Pa., and engineering laboratory in Voorheesville, N. Y., and will specialize in power development and transmission, water supply, sewerage and sewage disposal, public utility rates aid valuation.

Albert M. Wolf, C. E., and Lawrence M. Harper have associated under the firm name of Wolf & Harper, Engineers, to conduct a general engineering business, with offices at Room 1508, 7 West Madison St., Chicago. Mr. Wolf has for the past 10 years been associated with Condron Company, Engineers, Chicago, engaged in the design and supervision of construction of bridges and industrial buildings of all kinds, as principal assistant engineer in charge of design for five years and as engineer and secretary of the company for two years. Mr. Harper has been engaged in mechanical and structural engineering work for the past 12 years, having in that time served as mechanical engineer for the Condron Company, The Arnold Company, and the Northwest Engineering Company; as engineer in charge of construction for The Foundation Company, and as structural engineer for Herman J. Esser, Architect, Milwaukee. The new firm will specialize in the complete design of commercial and industrial buildings and structures, power plants, the valuation and appraisal of properties, and the preparation of engineering reports.

Obituaries

Richard H. Lamscha, civil engineer, died Jan. 10 at his home in Butler, N. J.

David Carlisle Humphreys, dean of the School of Applied Science of Washington and Lee University, died Jan. 10. Professor Humphreys was born at Chatham Hill, Va., Oct. 14, 1855. From 1879 to 1885 he was United States assistant engineer on improvements on the Missouri river. He became adjunct professor of applied mathematics at Washington and Lee University and in 1889 was elected professor of civil engineering and became dean of the school of applied science in 1904.

Industrial Notes

J. H. Libberton, formerly manager of the Service Bureau, Universal Portland Cement Co., member technical problems committee, Portland Cement Association, and member joint committee on standard specifications for concrete, is now connected with the General Chemical Co. at its offices, 25 Broad St., New York City. He will handle service and sales of Hard-N-Tyte, a chemical crystalline hardener for concrete.

Wm. R. Elden, for 14 years associated with the Lidgerwood Manufacturing Co. as engineer and salesman at its Chicago office, has resigned his position to join the organization of Sauerman Bros., 322 S. Dearborn St., Chicago. In this new position Mr. Elden's experience in designing and specifying hoisting engines will be utilized in preparing specifications for the power equipment furnished to purchasers of Sauerman dragline cableway excavators and Sauerman bottomless power scrapers.

The Hallidie Machinery Co., L. C. Smith Bldg., Seattle, Wash., has been appointed representatives of the Conveyors Corporation of America, Chicago, formerly the American Steam Conveyor Corporation. They will handle the sale of the American steam conveyor and American trolley carrier in the states of Washington and Oregon.

The Great Western Contracting Co., Kansas City, Mo., representatives for the Conveyors Corporation of America, Chicago, has changed the name of its organization to The Rawlings Industrial Equipment Co. This organization is sales engineer for the manufacturers of power plant machinery. Besides handling coal and ash conveyors for the Conveyors Corporation of America, it also is representative of the Springfield Boiler Co. and the Cooling Tower Co.

Building and Structural Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Pandering Politicians and the Duty of Professional Engineers

A charge persisted in without knowledge of the facts is nothing short of slander. This, in essence, was what Abraham Lincoln said (60 years ago) in his Cooper Union speech in New York City. We may safely broaden this generalization to read: Persistent statements not based on investigation of facts are tantamount to deliberate falsification.

We concede that the average man is as yet very careless in his assertions, and that he sees nothing reprehensible in being wrong. But when being wrong in an assertion works injury to someone, the asserter is morally but little above a common liar.

During the past few years when public utility owners and managers have been begging the public for relief from excessively low rates for services rendered, there have been numberless printed assertions by public officials to the effect that existing rates were high enough to yield a fair return upon actual investments. Even where appraisals by reputable engineers and audits by accountants have belied such assertions, rarely have the asserters had the honesty to investigate the facts. Instead, their usual practice has been to ignore all evidence and persist in their unprovable statements.

To such a pass has this form of immorality brought things that several state legislatures are to be asked to rescind laws relating to state regulation of public utility rates. When mayors and other public officials persist in telling the public that street railways can profitably carry passengers at 5 or 6 ct., is it any wonder that many people have come to regard state utility commissioners as being the tools of utility companies?

In one state the governor has ousted all the utility commissioners, because they incurred the ill will of certain people on account of rate increases granted to public utilities. In another state one of the most fearless and capable of utility commissioners has resigned, apparently disgusted with the charges made not merely by some mayors but by some newspapers that the commission has done nothing but raise utility rates unnecessarily. If the engineering societies in such states were a few years in advance of their present development, probably the public would receive authoritative expressions of engineering opinion that would contradict and perhaps silence the false statements of demagogic mayors. The time is certainly overripe for protests from associations of professional and business men against the baseless assertions and the selfish acts of politicians who are pandering to the worst side of human nature. The public would like to ride on street cars for a nickel. They would like better to ride for nothing. Hence the public is not only willing to be convinced, but is half convinced before any one has spoken that the "predatory railway kings" are robbing them. The silence of men who know better—engineers, business men and editors—is taken as evidence that the statements of the pandering politicians are true.

It will not do to excuse ourselves from the duty of speaking and acting now. We have "passed the buck" times without number, until a few more passings will find us all riding in street cars as slowly and expensively operated as the elevators in the typical city hall. America is face to face with municipal ownership of street car systems, of gas and electric plants. Steadily and with unrelenting pressure, the economic life of public utility companies is being squeezed out. State commissions and courts are trying to be just, but an ignorant public is constantly threatening them and doing all that it can to block their efforts. The ignorance of the public is mainly ascribable to the silence of the men who are most competent to speak not only with authority but with freedom from selfish motives—the professional engineers.

Whether there is to be municipal ownership of all utilities or not, professional engineers will be employed. Many engineers think that their chances of securing adequate compensation are better under public than under private administration. At all events there is so little to choose in that respect that engineers as a body can not be charged with selfish motives in advocating fair rates for public utility corporation services and fair treatment of public utility commissions.

Apropos of the unsound attitude of most municipal officials relative to public utility rates, we quote from a recent address before the League of California Municipalities by W. E. Creed, president of the Pacific Gas and Electric Co.:

> On the habit of jumping at conclusions without knowledge of the facts, I cite the official procedure when an application for increased rates is filed.
>
> The city council meets. It forthwith passes a resolution and instructs the city attorney to oppose the application. The city attorney issues his public pronouncement, duly accompanied by photograph, saying: "I will fight to the last ditch," as he raises his eyes to heaven and prays to God to give him strength that justice may triumph and right prevail.
>
> Never in all my experience, and I have been in the public utility business a good many years as a lawyer and as an executive, never in all my experience have I ever heard of, read, or seen a resolution by a city council directing a city attorney to investigate the facts and to reason from those facts to a sound conclusion in the public interest. Apparently some public officials are not concerned about the facts, but are stalwart nevertheless in their conclusions.
>
> A rate inquiry ought not to be an adversary proceeding, but should be a mutual and co-operative investigation of the facts, proceeding upon the theory that either too high or too low a rate is an injury both to the utility and to the public.

Where Six Men Are Required [to Do the Work of Two

Building contractors have witnessed a growing tendency on the part of the unions to specify in great detail what kind of work each class of worker shall be permitted to do. Such restrictions are by no means confined to the building trades. For example, the following testimony was recently given by E. T. Whiter before the U. S. Railroad Labor Board:

> A headlight generator to be removed and replaced requires the electrician to disconnect the wires, the sheet metal worker to disconnect the pipes, a machinist to unbolt and remove the generator and apply a new generator, the sheet metal worker to connect the pipes and the electrician to connect the wires. As these employes usually have helpers, it means six men are employed on a job that ordinarily should be done by a machinist and helper.

Craft rules of this sort should be opposed with the utmost vigor. But building contractors have been inclined in recent years to accept such rules, and pass along to building owners the added cost of construction, rather than engage in a controversy that might tie up construction for an indefinite time. However, American employers in other lines seem to have reached the limit of their patience. Illustrative of a determination not to countenance such restrictions we may cite the recent announcement of William Cramp and Sons, the great ship builders, that:

> We expect our employes to ignore all laws enacted by labor organizations for the restriction of output. It is our intent to deal fairly and justly with the rates of pay, and we shall expect our employ in return to give us an honest output for each hour of employment.

We believe that the main objection that most employers have to the "closed shop" is viewed in the quotation just given. When labor unions cease practices intended to limit output, much of the opposition to labor unions will cease. Unfortunately that day seems far off, for while some labor leaders have announced their belief in the doctrine of unrestricted output, none have yet begun an active campaign to rid the unions of restrictive practices.

The "full crew laws" that have been passed in several states are still fresh in the minds of railway executives, nor can they forget how the unions persuaded the government to abolish the "piece rate system" in railway shops. Such object lessons have also had a profound effect upon other American employers than those in the railway field. Nor can they have failed also te see the significance of such facts as the enormous restriction of output by British coal miners and their steadfast opposition to the introduction of coal cutting machines.

The Decline in Prices of Construction Materials

The wholesale commodity index price of the Bureau of Labor averaged 189 for December, as compared with an average of 100 for the year 1913. The average for metals was 157 and for building materials it was 266 for December. Metals have therefore declined 20 per cent and building materials have declined 22 per cent from the "peak" prices of last April. Metals have apparently reached "bed rock", but the average of building materials is still high.

It is interesting to note that metals averaged 184 and building materials 164 for December 1918, at a time when the average of all commodities was 206.

The U. S. Steel Corporation should be given credit for having kept steel prices from joining the enormous inflation that occurred in 1919 and 1920, the peak of which was reached in May 1920, when the average commodity price index was 272. Had all other manufacturers of construction materials followed a similar policy, there would have occurred no such slump in building activity as marked the close of 1920. In May, 1919, the index price of building materials was 164, but a year later it had risen to 341, thus more than doubling; whereas metals rose from 152 to 193 during the same period; or an increase of less than 30 per cent.

The U. S. Steel Corporation was running its plants in December at 90 per cent of their capacity, which speaks for itself as to the wisdom of holding to moderate prices rather than attempting to charge all that the market would stand temporarily.

The index price of building materials was 313 for October and 274 for November, indicating a decline of 13 per cent in one month; but for December it was 266, indicating a decline of 3 per cent. A further marked decline before April is probable.

Temper Brittleness of Steels.—An extensive review of the literature on this subject has been made the result of which is summarized as follows in the Jan. 7 Technical News Letter of the U. S. Bureau of Standards: Certain steels which have been hardened by quenching from temperatures above the A3 point and tempered at temperatures ranging from about 450 to 600° C. show less impact values if they are cooled slowly from tempering temperature as compared with those cooled quickly. The cause of this prenomenon, which is also referred to as "Krupp Frankheit", has not yet been clearly established. The property of temper brittleness has been found present in carbon steels .25 to 4. per cent C., nickel, chrome-nickel, chromium, and certain other alloy steels. Chrome-nickel steels of the same chemical composition and heat treatment have been found to vary widely in their susceptibility to temper brittleness and even in the opposite direction, i. e., the slowly-cooled specimens were tougher than the quickly-cooled ones. The process of manufacture appears to have more of an influence than small changes in chemical composition, thus, steels made by the acid open-hearth process are more prone to temper brittleness than electric or crucible steels. The opinion has been advanced that the degree of work and the temperatures employed during the process of fabrication from the ingot bear some relation to the degree of susceptibility to temper brittleness. Other factors appearing to have an influence on the subject are the temperature of hardening preceding tempering treatment, degree of hardening, as cooling in water, oil or air, the rate of cooling from tempering temperature, phosphorous content, and the furnace atmosphere in which the material is treated. Other questions bearing upon the problem and upon some of which no general agreement has been reached and concerning which but little knowledge appears to be available are: relations between microstructure and susceptibility to temperature brittleness, path of rupture, heating and cooling curves, relation between impact values and tensile test values as well as the Brinell hardness values, and the influence of the shape of the notched specimen upon impact test values.

A. A. E. Has Over 24,000 Members.—The American Association of Engineers had 24,026 members at the close of business on Jan. 13. Two years ago on that date the membership was about 2,400.

Methods and Plant for Constructing Concrete Substructure of New York County Court House

A combination of mixing, hauling and spouting units designed especially to meet the conditions of the job is being used in the construction of the concrete substructure for the new $20,000,000 court house for New York County. This structure is being erected on Center St., New York City, a few hundred feet from the great municipal building. The contract for the substructure was awarded Aug. 15, 1920, to Rodgers & Hagerty, Inc., New York City, for about $2,000,000. The excavation required under this contract was about 500 ft. long, 320 ft. wide and 30 ft. deep and involved the removal of 94,000 cu. yd. of material. This excavation work was described in our Jan. 19 issue.

Installation of Concrete Distributing Plant, Aggregate Storage, Mixing Plant and Ramp at Left. Slide for Reinforcement Bars at Right.

Type of Sub-Structure.—The masonry included in the contract consists of foundation rings, the sub-basement floor and the exterior walls extending up to street grade.

The foundation ring system consists of four concentric, reinforced concrete rings, the outer two being hexagonal in plan and the inner two being circular. The extreme outside ring supports the exterior walls, these walls in turn forming the archways of the completed building. It is proposed to make the floor a reinforced concrete slab about 2 ft. thick, the top of this slab system being at the same elevation as the tops of the concentric footings and supported on haunch walls, which are a part of the rings. As the floor will be subjected to hydrostatic pressure from below, the slab will be anchored down to the footings by a system of steel bar reinforcing.

A very large amount of steel reinforcement is embedded in horizontal planes near the tops and bottoms of the rings, besides vertical reinforcement bars. Inside the center ring there are eight small independent rectangular column piers. The concrete in the sub-structure has a total volume of about 19,000 cu. yd. of 1:2:4 mixture made with 1-in. broken stone and reinforced with about 1,250 tons of Havemeyer deformed bars, most of them in mill lengths of 38 ft., bent parallel to the curves of the rings.

Concreting System.—Since the concrete footings included in the Rodgers & Hagerty contract occupy more than one-half of the area of the excavation and were to be constructed simultaneously with the completion of the excavation of the footing trenches, and since the concrete is placed in the form of several complete rings with comparatively narrow annular spaces between them, a system of distribution of concrete on the surface of the pit or by means of cableways or derricks would have involved the use of transporting apparatus that would greatly interfere with construction operations, the form work and the finished and unfinished portions of the concrete. It was also evident that there was no room for a mixing plant concentric with the work nor opportunity of access to and from it had it been installed there. Consequently an isolated mixer plant and a special system of conveying and distribution was necessary that would not interfere with the operations that practically covered all of the excavated pit.

The problem was studied by the engineering department of R. E. Brooks Co., 50 Church St., New York, which worked out a satisfactory solution and design for the conveying and distribution plant eventually installed by the contractor, with the assistance of plant engineers, F. I. Ginsberg, E. Gwynn and Robinson, in co-operation with F. W. Allen, chief engineer for the contractors. This system is very simple and efficient and will, it is estimated, save a considerable percentage of the cost that would have been involved by the adoption of any of the other methods under consideration at the time the contract was awarded. It harmonizes well with the policy of excavation which executed all of that work with improved appliances and power machinery, practically eliminating hand labor. It secures a better quality of work, more rapid execution, eliminates liability of delay from labor troubles and affords very considerable advantages by the use of the most efficient plant and capable workmen.

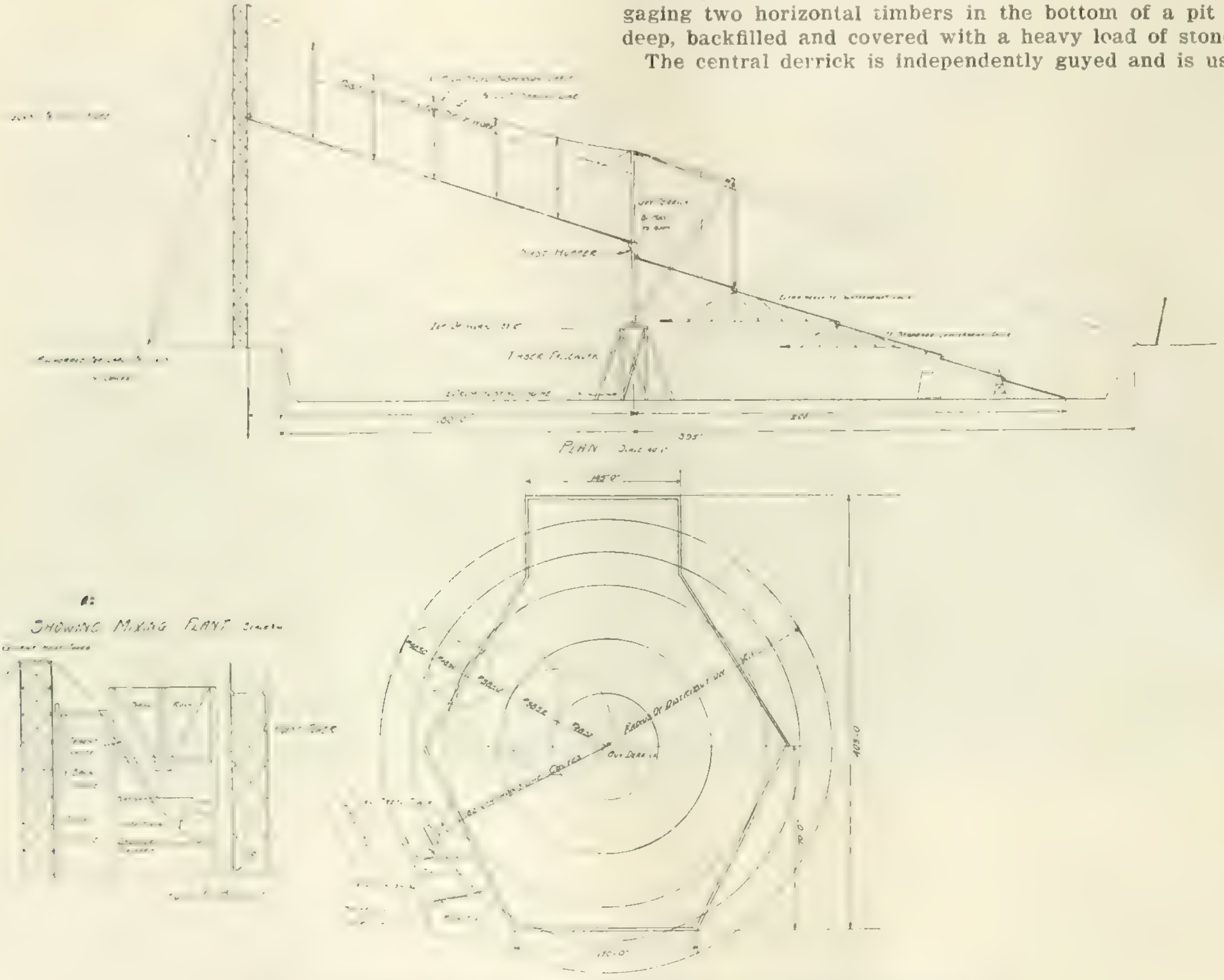
The essential features were the selection, combination and installation of standard high-class plant, the value of which has been abundantly demonstrated in previous successful operations, and which were so combined and arranged as to give the required service with rapidity, economy and reliability without involving any experimental features, elaborate arrangement or unusual operations requiring especially skilled attention.

The plant is composed of units of commercial apparatus so co-ordinated and arranged as to be very flexible in operation, to be easily manipulated and to involve little or no waste construction.

Part of the contractor's regular stock equipment was utilized advantageously, and the remainder of the plant which was installed is not only adapted to secure the greatest rapidity, efficiency and economy of construction of this work but to be desirable as permanent equipment available for almost any kind of heavy concrete construction.

On the completion of the present contract the plant may be transferred to some other job, or may be sold in the open market for a price which, subtracted from the purchase price, should leave a small difference that would represent a very light unit charge for handling and mixing the concrete.

The general system is that of mixing the concrete on the site at a point entirely outside of the excavation and construction work, hoisting it to a height of about 120 ft., and then spouting it directly to position in the forms. The special feature is the arrangement by which the concrete is conveyed from the hoisting tower to the geometric center of the construction and thence distributed by a duplex system of pivoted chutes to any point within a radius of about 200 ft., all of the appartus being kept at a comparatively high elevation with unobstructed clearance beneath it for the operation of the steam shovels, pumps, pump lines, form construction and concreting over every part of the area to be built, thus avoiding all interference, delays, or expense of removing and rehandling plant, equipment or materials.



Plan and Location Diagrams of Concrete Mixing, Hoisting and Spouting Plant.

Excepting electricity for lighting, operating the centrifugal pumps and some minor uses which is purchased from a commercial company, power is furnished by a 250-HP. battery of three horizontal steam boilers, although two of them, working to capacity, can provide for all the machinery now operated, with a consumption of between 5 and 6 tons of coke per 24-hour day, most of this steam being used in the 8-hour day shift. Ordinarily the principal requirements are for the operations of the two hoisting engines, the pile driver hammer, the concrete mixer, the cement hoist and the concrete hoist and reserve Cameron pumps.

The Spouting System.—The 1-yd. concrete mixer is installed about 10 ft. above the surface of the ground in the base of a wooden tower 35 ft. high, surmounted by a 10-yd. and a 20-yd. storage bin for sand and broken stone. The mixer discharges directly into a 1-yd. quick-shift bucket hoisted in an Insley steel tower 160 ft. high. The bucket automatically discharges into a hopper fixed on a sliding frame at any required height in the tower, from which the concrete is distributed through an Insley continuous line chute suspended from a 1¼-in. plow steel cable led from the tower to the top of the mast of the guy derrick installed on a wooden falsework tower 30 ft. high in the geometric center of the building.

From the top of the 70-ft. mast the cable continues to anchorage to a deadman located on the site beyond the limit of the general excavation. The end of the cable is looped around a sheave that is shackled to a 2-in. turnbuckle with 2-ft. adjustment that is connected to a wire rope loop engaging two horizontal timbers in the bottom of a pit 10 ft. deep, backfilled and covered with a heavy load of stone.

The central derrick is independently guyed and is used to support the counterweight chutes and auxiliary chutes in the center of the operation. This derrick is rigged up with bull-wheel, and with the use of the boom swinging engine in the base of the derrick structure proper, can be handled by one man without any loss of time. At the end of the 50-ft. boom section chute there is suspended from the end of the boom a 50-ft. extra heavy counterweight section chute which in turn supports a 50-ft. standard counterweight chute which gives a radius of 150 ft.; which radius is increased 60 ft. by the use of additional chutes which give a complete working radius of 210 ft. from the center of the building.

The entire arrangement of counterweighted truss and boom chutes can revolve 360° around the center of the building and each of the counter weighted chutes can revolve 360° at any point of the concentric circle it makes in the derrick revolution, thus fully commanding all portions of the area of the building. The first truss has a 5,000-lb. concrete counterweight and the second one has a 1,000-lb. counterweight, while the load suspended from the boom hook is about 20,000 lb. The chutes have a slope of 1 on 3, which provides for free delivery of concrete at all times.

So far the best day's record is 470 yd. with a total force of about 20 men, only 3 men being required to convey the concrete to the forms. The concrete is of medium consistency so that it immediately settles to a horizontal surface in the forms and does not require tamping or spading. At the end of every shift the concrete bucket and the line of chutes are washed out with water to prevent any concrete from adhering or setting on them, and at the commencement of every shift the chutes are also flushed with water to provide for the more easy flow of the concrete.

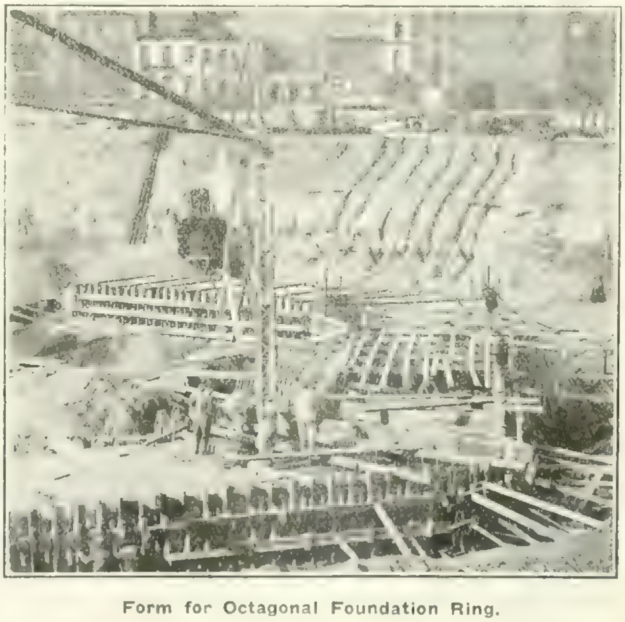
Pouring Concrete in Outer Forms From Duplex Revolving Spouts.

Handling Concrete Materials.—For the sub-structure contract there are required about 17,000 yd. of 1-in. broken stone from the Calvin Tompkins quarries at Tompkins Cove, on the Hudson River, 9,000 yd. of sand from Cow Bay, Long Island, and 114,000 bags of Portland cement of the Pennsylvania Cement Co.'s brand, all of which are delivered by the contractor's fleet of about 50 Pierce-Arrow motor trucks.

The cement is hauled about half a mile from the dock to the cement storage shed, which has a capacity of 30,000 bags. From here it is loaded by hand into a 1-yd. steel bucket hoisted in a steel tower about 40 ft. high to the charging platform of the concrete mixer, where the bags are opened and emptied by hand into the charging hopper and the empty bags dropped through a chute in the floor to the bag house, where they are cleaned by a hand-operated Century cement bag shaker that recovers 2 or 3 bags of cement from every 100 empty bags. The empty bags are placed in a Rowe baling machine, which folds and compresses them and holds them while they are securely wired in lots of 50. This arrangement insures a considerable economy in saving cement and bags and in preparing the bags for transportation so that none can be lost, damaged or withdrawn from the package in transit.

Sand and broken stone are delivered at the pier at the foot of Jefferson St., East River, on barges of 500 to 600 yd. capacity, which are unloaded by a 1-yd. clam-shell bucket operated by a derrick and hoisting engine which deliver to an elevated hopper bin of 15 yd. capacity which is used alternately for stone and sand. The bottom of the bin is about 8 ft. above the deck of the pier, with clearance under it for the motor trucks that are spotted there while the operator opens both of the two gates and fills the trucks in about 1 minute. Each truck averages from 20 to 22 round trips in one 8-hour shift.

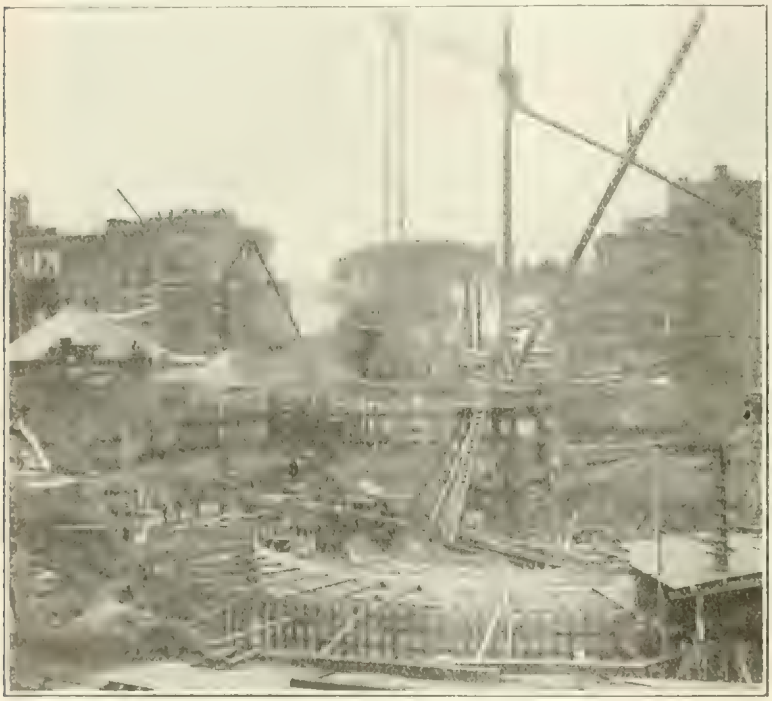
At the court house the trucks are backed up a plank paved incline fill against a timber sill over which they dump at the edge of the storage pile, the lower portion of which is partly confined by wooden bulkhead walls. A 1½-yd. clamshell bucket operated by a 60-ft. derrick boom reclaims the stone and sand dumped from the trucks and constantly keeps filled the small bins in the concrete tower. When not employed in this service it reclaims the sand and stone dumped



Form for Octagonal Foundation Ring.

at the foot of the storage [illegible] always located a [illegible] ery of the hopper is [illegible] drawn through bottom gates in the elevated bins to the charging hopper, so that the mixer can be operated at maximum speed. [illegible] under the bottoms of the storage piles so that in cold weather the entire piles can be heated and keep the aggregate at a suitable temperature for mixing whenever the temperature is high enough to permit the concrete work to be carried on. Provisions are also made for heating the concrete mixing water with live steam if necessary.

Concrete Forms.—The foundation walls are built successively and each ring is built in successive sections in wooden forms made up of panels about 20 ft. long and 7 ft. high, built on carpenters' benches adjacent to the work and put in position by hand. They are of very simple construction, made of 1-in. tongue-and-grooved boards. The larger pieces are built first and are stripped after the concrete is from 24 to 36 hours old, thoroughly scraped, and reassembled for the next section, and so on, thus using them from 3 to 5 times each. A force of carpenters are continually occupied in building, setting, stripping and cleaning the forms.



Pairs of Curved Reinforcement Bars Used as Rangers on Concrete Forms.

The form panels are set against vertical outside posts usually made of 3x6-in. timber, spaced about 4 ft. apart. These timbers are connected by plain horizontal ½-in. round rods 2 ft. apart vertically that pass transversely through the forms and are permanently left there. They are made of ample length and project beyond the faces of the verticals, where they pass through "Universal clamps" provided with set screws. These clamps are adjusted to the right position which determines the width of the forms, after which operation the set screws are screwed up tightly, holding the panels in position against internal pressure and obviating the necessity of cutting threads on the ends of the rods. The rods are heavy enough to resist considerable pressure from the wet concrete and stiff enough not to unduly sag in the long span between the sides of the form, and also serve to support and hold in position any of the reinforcement bars which are wired to them.

When the forms are to be stripped it is only necessary to loosen the set screws, remove the clamps, and take off the verticals and panels, leaving the ½-in. rods projecting several inches beyond the face of the concrete. These projections are then cut off flush with the surface of the concrete, leaving no holes to be pointed and no steel outside the concrete.

Reinforcement Steel.—Notwithstanding their massive character, their abundant bearing surface, and the excellent quality of the sand on which they are seated, the foundation walls are reinforced with a very large amount of reinforcement bars up to 1-in. square, and usually in 38-ft. lengths as received from the mill. Near the bottom of the wall there are four tiers of rods about 4 to 6 in. apart; two tiers being transverse under column bearings and two tiers longitudinal The bottom tier rods are supported on concrete blocks manufactured at the site and are wired together at intersections, forming a complete, independent framework, put in position before the concreting is commenced. In the upper part of the wall there are two tiers of horizontal rods corresponding to those in the bottom, and suspended by wire rope loops from transverse caps reaching across the forms from side to side.

The reinforcement bars are delivered by motor trucks and skidded to the bottom of the excavation on four lines of inclined timbers on the slope of the pit, and at the bottom are assorted, stored, cut to length and bent as required. The longitudinal rods in the curved rings are all bent to the required radius in a motor driven 3-roll bender at the rate of 80 bars per hour, by a gang of 6 men supplying and taking away the bars from the machine.

These curved bars have been utilized for outside walling pieces on the forms, pairs of bars being set at top, bottom and intermediate points of the verticals, and wired in position, thus saving a considerable amount of timber and the work of cutting it to the proper curvature, as well as presenting a neater appearance, being more convenient, and without at all injuring the steel for its final use as reinforcement in the concrete.

The spacers used to separate the bottom tiers of reinforcement rods and keep them above the bottom of the forms have a uniform thickness of 3 in. and are made of 1:2 cement mortar cast in slabs about 6 ft. wide and 10 ft. long on wooden platforms with removable side pieces 3 in. high on each of the four sides. These pieces are clamped in position and the space between them is filled with mortar, screeded off to the level of the tops of the side strips. As soon as the mortar is sufficiently set a straight edge is laid across, connecting corresponding marks on opposite sides, and serves as a guide for a thin-bladed scoring tool which cuts through the full thickness of the slabs, dividing the concrete into strips 3 in. wide and about 18 in. long. After these have set from 12 to 24 hours, the side pieces are removed and the small pieces are detached if necessary by again cutting through the joints with the scoring tool. They are then ready for placing in the forms, where they make an integral part of the monolithic mass, thus providing for the accurate positioning of the steel without introducing any foreign or objectionable element into the concrete. The blocks are made by 3 men who can readily turn out 2,000 in one 8-hour shift.

Guy Lowell, the architect, is represented by a well-organized staff, including Major John H. House, Jr., in general charge; Wm. B. Claflin, superintendent of construction; E. W. Jacobus, clerk of the works, and Harry W. Andrews, designing engineer of structural steel. Moran, Maurice & Proctor are consulting engineers for the foundations.

On Dec. 1, Rodgers & Hagerty, Inc., had completed about 70 per cent of the contract and work is being vigorously prosecuted by an average force of 200 men under the direction of Field Superintendent Harry Stone and Managing Field Engineer Walter Caccia. James J. Kelly, of this organization, is in charge of the surveying parties required for the work.

Recent Government Publications on Paints.—The following circulars are now ready for distribution and may be bought from the Superintendent of Documents, Washington, D. C., at 5 ct. a copy: Bureau of Standards Circular 102—Recommended specification for composite thinner for thinning semi-paste paints when the use of straight linseed oil is not justified; Circular 103—Recommended specification for Spar varnish; Circular 104—Recommended specification for asphalt varnish; Circular 105—Recommended specification for liquid paint drier.

Solving the Housing Problem

By CHAS. F. DINGMAN,

Engineer, Flynt Building & Construction Co., Palmer, Mass., Charlotte, S. C., and New York City.

Before we can properly attempt the solution of the problem of present distressing housing shortage it is necessary that we should know just what the problem is and how it came to exist as a problem.

There seems to be a general impression, particularly among people living outside of the larger cities, that the housing problem is something of very recent origin. Those who have lived in the large cities know that the housing problem has existed there for a long, long time, but that it has recently become much more universal and much more acute.

The problem in the cities has not always been merely a question of a sufficient number of flats, tenements, or apartments, as they may be termed, but has also been a question of sufficient light, air, comfort and privacy. And—without sufficient light, air, comfort and privacy it is absolutely impossible to maintain those standards of public health and morality that are essential to the development of an orderly, self-respecting and law-abiding citizenry.

During the recent war the rapidly mounting costs of all those things which enter into the construction of dwellings, as well as the restrictions imposed by the Government, caused an almost absolute stoppage of house construction except for a few developments undertaken by Governmental departments in connection with war work.

Before the war the speculative builder, who put up great numbers of houses and disposed of them individually upon comparatively easy terms of payment, had been one of the most important factors in supplying the continual need for new homes in and near the larger and more rapidly growing communities, while the individual owner and the man who built to rent usually took care of the demand in the smaller communities and the industries which were situated away from the centers of population provided homes for some portion of their own employes.

The war, however, with its upsetting of all established price levels, completely eliminated the speculative builder and the builder of small means from the field. Continually mounting costs have kept them out of the field until quite recently and have very effectually checked all but the most necessary housing projects of the industries.

So now we find ourselves facing a nationwide shortage of nearly a million homes. It is true that just at present the shortage of work occupies a more prominent place in the public mind than does the shortage of homes, but the shortage is still there and will become even more prominently noticeable, as soon as employment conditions become normal again. Meanwhile, short sighted policies and actual shortage of ready funds conspire to increase the shortage of homes by failing to take advantage of the present available surplus of labor and put it to work building homes.

If we would realize how great this shortage of homes is we need only stop and consider that it would require at least five years of the most active work (660,000 new homes constructed per year) to bring us even to the same ratio of number of homes to number of families that existed just before the war.

In 1916, when the average cost of all buildings, houses, factories, etc., was only $1.82 per square foot, we were spending at the rate of $475,000,000 per year for new homes. In 1920, with an average cost per square foot of $4.32, about two and three-quarter times as much as in 1916, we only spent $591,000,000.

This means that we only built about half as many new homes in 1920 as in 1916, yet our population was appreciably larger and we still had the great deficiencies of 1917 and 1918 to make up.

There are many people who have felt that, because automobiles are becoming cheaper and because commodity prices in general have declined sharply, building material prices must come down and stay down.

It is true that building material prices have fallen sharply in the recent past, whether they will remain down or will start upward again shortly is a matter of conjecture, but there are many reasons why a rising scale of building material prices may safely be predicted.

In the first place, while building material prices are, of course, regulated in a general way by the same forces which regulate the prices of all commodities, building material prices have been subjected to some very exceptional forces in the recent past. The effect of this is shown by a comparison of the graph of building material prices and general commodity prices.

Building material prices lagged behind general commodity prices in the upward climb until the effect of the war's great drain upon the available timber supply and the exhaustion of all reserve stocks of manufactured building materials was felt. Then building material prices overtook general commodity prices and have kept above them ever since.

The drain which was made upon the available supply of structural timber is something that cannot be made up for many years. The great need for houses will increase rather than decrease the demand for lumber and timber.

Over $300,000,000 was voted for public improvements at the last general election; this is only a partial report and does not cover the entire country, and all of these improvements use some of the same kinds of materials and labor as are used in buildings.

Two and a half billion dollars worth of buildings were projected last year that have not yet been placed under contract.

So it seems that any house construction program may be safely undertaken now without fear that the value of the investment will shrink materially in the near future.

So much for the problem and its causes. The solution is, of course, to build houses. The new problem of size, type and kind of houses and, possibly even more important, the problem of financing then present themselves for solution.

It is not practicable to offer one general plan that will be suitable for every community. Local conditions of population, industries, transportation, climate and topography must be given due consideration, so the best that can be done here is to state what has been done in other communities.

Perhaps the most satisfactory method of supplying homes, from an employer's viewpoint, is to have each industry provide and own houses which they rent to their employes. This arrangement insures the industry that it will have homes for the people it desires to employ and makes it practicable to retain a particularly desirable class of employes.

Years ago mill-owned tenements were not very attractive structures; recently, however, the tendency has been to supply such attractive, comfortable homes at such reasonable rents that no private landlord can hope to build tenements in the same village and rent them at a figure that will return the interest on his investment.

In communities where several industries draw upon the resident supply of labor home building corporations have been formed to provide the houses and either sell them or rent them to the occupants.

Among other cities and towns where home building corporations have operated with satisfactory results are Reading, Pa.; Keene, N. H.; Poughkeepsie, N. Y.; Tonawanda and North Tonawanda, N. Y.; Gastonia, N. C., and Richmond, Va. In each of these places I understand that the corporation was organized by the local Chamber of Commerce.

The plan in Reading was to secure 25 business men who would each subscribe $5,000 to the initial fund and the money thus obtained was used to build 25 houses, each containing six rooms and a bath.

The houses were built in blocks of five and are sold at $5,500 for the end houses and $4,750 for the others. This is a much lower figure than it has been possible to obtain in New England; the average cost per room of most well constructed developments has ranged from $1,000 to $1,400 per room, exclusive of land and improvements.

In New Jersey a rather extensive bungalow development has been undertaken by a speculative builder and his prices run about $1,550 per room, including land and improvements, which would equal about $1,400 per room for the house only.

The payment plan used in selling the houses at Reading is one which would be feasible in almost every community.

It only requires an initial payment of $500, the balance is taken care of as follows:

First mortgage [illegible]	$2,850.00
Second mortgage [illegible]	950.00
Net [illegible] to be paid off [illegible]	450.00
	$4,250.00

The monthly payments can then be so arranged that they cover all interest charges and a sufficient amount on the principal to retire the second mortgage in 10 years or less.

The method pursued in Poughkeepsie is very much similar to that at Reading except that the Poughkeepsie company rents houses, when available, to those who do not d-sire to purchase.

Besides those places where housing corporations have been operating successfully there are many other communities where corporations have been organized but have not yet commenced operations. In a great many instances the delay is due to a belief that it will be possible to build houses much more economically later on than it is at present. In more cases it has been because the cost of building houses was underestimated in the first place and sufficient financing was not arranged for.

At Pittsfield, Mass., the General Electric Co. has established a Homebuilding Bureau for the purpose of encouraging employes to provide themselves with homes. The Bureau does not build or sell houses but employs an engineer who advises the employes, aids in drawing up contracts and inspects houses during their construction.

The engineer of the Bureau also arranges for a first mortgage loan of about 60 per cent at one of the local banks and a second mortgage loan of about 30 per cent with the G. E. Employes' Homebuilding Trust. This makes it necessary for the employe to finance only about 10 per cent of the cost of his home immediately.

I recently wrote to a great number of bank officials in all of the New England states and asked them for their ideas as to what could be done to provide the many homes that are needed right now. Bankers are naturally greatly interested in any movement that will promote the prosperity of their communities, because the prosperity of the community and of the bank are likely to be very closely related. I found that, while most bankers do not feel in a position to take the initiative in any building projects, they are willing to do their fair share of the financing of any house construction that is undertaken on a well considered, conservative plan.

Of course, during the recent past, many bankers have felt that construction costs were grossly inflated and, for that reason, have not been as liberal as they might have been in fixing the amount to be loaned on a property. I think that feeling is now past and the loans are more likely to come up to promoter's expectations.

I also wrote to the secretaries of commercial organizations in cities and towns all over the eastern states to get an idea of what the actual demand was. Only two cities, Toledo, O., and Wilmington, Del., reported a surplus of houses.

In Wilmington the surplus was explained by the fact that the closing down of our industries had caused thousands of people to move away and in Toledo the surplus is so small that it will probably be wiped out very soon.

Every other secretary who replied reported a very keen demand for more houses and many reported that plans are now under way to form housing corporations or to relieve the shortage in some way.

A New Concrete Floor Hardener

A chemical compound for hardening the surface of concrete floors and making them water tight has been placed on the market by the General Chemical Co., 25 Broad St., New York City. The compound is known as "Hard-N-Tyte." It is sold in crystal form and the solution is easily made on the job by dissolving the crystals in water. The solution is flushed on the surface and spread with a long handled brush or broom. For sidewalls the application is made with a brush. It is stated that the expense of treating concrete with "Hard-N-Tyte" approximates 2 ct. per square foot, including the labor for application.

Should the Builder Be Licensed?

In an article in our Dec. 22 issue Mr. O. W. Rosenthal, president Rosenthal-Cornell Co., Chicago, advocated licenses for building contractors. The negative side of this question is set forth by Mr. C. A. Crane, secretary General Contractors' Association of New York, in the December Bulletin of the Associated General Contractors, from which we quote as follows:

This is not a new question by any means. It has been under consideration by the Associated General Contractors almost from the organization meeting. Bills with that object in view have been introduced the past few years in many State Legislatures. New York had one a few years ago to license all builders in concrete construction. As we recall, it died in committee, and but one contractor appeared to speak in its favor. It was opposed by the New York General Contractors' Association.

If a State license were to be a guarantee of integrity and responsibility, we would be for it. Mr. Rosenthal's article infers that it would, but we disagree with his conclusions. It would add nothing to the reputation of the reliable builder, but would be exploited by the irresponsible holder as evidence of fitness he did not possess. The answer of those favoring license will be that the requirements and examinations should be so strict and searching that none but the reliable could qualify. Again we say if that could be assured, we'd be for it. Examinations, however, do not develop proof of reliability and integrity; they can do no more than reveal a certain amount, more or less, of theoretical knowledge with a statement of the applicant's experience on which his practical knowledge is based.

Licensing a Reporter to Be a Plumber.—Some years ago an enterprising reporter took a series of civil service examinations in New York for professional and mechancial positions in the city's service. Without any practical experience in any of them he passed every test with a high average, and was offered appointments to several positions, not one of which he was qualified to fill. As we recall, he passed at the head of the list in the plumbers' examination, although he had never wiped a joint in his life and didn't know red lead from solder. His purpose was to write a story exposing the fallibility of civil service examinations and showing that they were no protection against the employment of incompetents. Positions of higher responsibility such as chief engineer are not usually in the classified civil service. Such appointments are made not as the result of an examination, but because the appointee has demonstrated some pre-eminent ability in his particular calling.

What Makes a Builder?—How many builders in the country could offhand qualify on even the simplest of technical questions? There are any number of first class, capable contractors and builders who couldn't read a blue print to save their lives. They hire men to do that, but they have that something in them which no amount of book-learning or even experience can instill—that contractor's sixth sense that some men seem born with, and without which no one becomes a big, successful contractor. As evidence of this, how many engineers who have made great reputations in their profession, have succeeded as contractors? Yet they could pass the toughest technical examination with flying colors.

Mr. Rosenthal cites as an argument for licensing the builder, the fact of state control over doctors, lawyers, architects and engineers. We think the comparison is far-fetched. A thorough university training is indispensable for the practice of those professions, and we are not convinced, nor have we heard it advanced, that a college education, is a sine que non for a builder. Doctors' and lawyers' operations are based on confidential personal relations, the very nature of which requires that only the selected few shall be permitted to practice. The control by license of architects and engineers is comparatively new and has been adopted by 11 states thus far. We think it proper that the man upon whose design the safety of a structure depends, should demonstrate his capacity and knowledge for making the design before being permitted to hang out his shingle. We think the records will show there have been more building and structural failures through faulty design than faulty methods of construction. A strict license law for architects and engineers will do more to safeguard building than licensing the builder.

Is Contracting a Business or a Profession?—Contracting is more of a business than a profession. Certain elements in it require professional men, technical graduates, and so do certain elements in the manufacture of steel, but does any one contend that the steel manufacturer should be licensed? Contractors are manufacturers in a sense—in some instances, legal decisions have been rendered to that effect. They are assemblers of material to form a finished product. Skill and experience are necessary—absolutely essential—to do that assembling correctly, just as they are necessary to the successful iron-master. But more than skill and experience in the mere assembling are necessary for the successful builder or contractor. Like the iron-master, merchant or manufacturer, he must be a sound financier, a trained executive, an able administrative. Without these qualities all the technical knowledge in the world couldn't make him a successful builder. And examinations would fail to reveal them.

For these reasons we fail to see how the public would benefit or be protected by a license law for builders. Even in those professions which it is concededly proper to license, the mere fact of the license does not bring or hold clients. Success with the lawyer, doctor, architect, or engineer depends on the personal equation. It is the inevitable rule of the surival of the fittest that places the best at the forefront. Reputation brings business, and so it will be always.

What Determines Reliability?—If an owner selects a builder merely because his bid was the lowest, without inquiring into his reputation, that is lamentably poor business on the owner's part. If the builder makes a mess of it, he won't do any more work for that particular owner and sooner or later, will automatically be driven out of the building business. Such failures don't injure the responsible builder—in the end they help him. New men will always be breaking into the game, and license or no license, only a few will succeed.

A license law for any class of business is defensible on two grounds; that the business is of such nature that it should be under control of the police power of the community; and that the license fees produce substantial revenue. Neither one of these in our opinion applies to the building business. Governmental regulation of business tends to political interference and usually results in the last state of affairs being worse than the first. We think it was President-elect Harding who said we needed less Government in business and more business in the Government. We're for that idea.

Hardness of Steels Produced by Abrasion.—The relative hardness of various types of steels produced by subjecting all to the same abrading influences has been determined by the U. S. Bureau of Standards with the following results: In all cases except the high-carbon austenitic steel, no pronounced effect of the abrasion upon the steels used in these experiments was observed. In all cases the hardness of plain carbon steels is increased among steels of this type the steel containing 0.85 per cent shows the greatest increase in hardness. The alloy steels generally show a smaller increase in hardness of abraded surface than plain carbon steels, and in some cases they show a decrease of surface hardness. High-carbon austenitic steel shows a marked decrease of Brinell and scleroscope hardness. This process of abrasion viewed in the light of Beilby's Theory may be considered as resulting in the production of amorphous matter at the expense of crystalline matter which affects the hardness of the abraded surface of the metal but probably not the general character of its structure. As to the decrease of Brinell and scleroscope hardness of high-carbon austenitic steel, the following explanation may be suggested: According to Benedick's Pressure Theory, the martensite should be present in a greater amount on the lower layer of the examined specimen than in the inner portion and it seems possible that if the surface layer is ground away the next or more austenitic layer should be found to be somewhat softer.

December Contracts of Fabricating Shops.—The records of the Bridge Builders' & Structural Society, from reports collected by its secretary, show that during the month of December, 1920, 47,000 tons of fabricated structural steel were contracted for throughout the United States, equivalent to 26 per cent of the entire capacity of the bridge and structural shops of the country.

Cost Factors of Engineering Practice*

By CHARLES H. YOUNG,

President Central States Engineering Co., Muscatine, Iowa.

In attempting to analyze the subject of cost factors in engineering practice it was discovered that they were of a great variety and were dependent upon the class of service that an engineer in practice performed. There are involved, also, the kind of organization, the kind and extent of trade area tributary to the locality within which the engineer functions and the amount of energy spent in educational work of clients and of the engineer, himself, in continuance of business, the manner of development and the period of development.

It seems that there is no general method of procedure adopted by the various engineers, so that a standardization of factors could not be made applicable to each and every [illegible]

Classes of Engineers.—It is therefore necessary to divide the engineers into seven (7) classes:

Class A, an engineer who may or may not have a technical education, who has office at home and operates a one man practice.

Class B, an engineer who has a small office and employs assistants part time and operates balance of time in one man practice.

Class C, an engineer who has business organization, stenographer, chief engineer, and departments, employing a number of men in order that he may perform various classes of service.

Class D, an engineer who holds some position which provides office equipment and salary and devotes part time to private practice.

Class E, a professor who devotes excess time to private practice in order that he may gain such experience as will enable him to be better qualified to teach the subject which he has in hand.

Class F, an engineer who consults only on special projects and confines himself to development on only large projects along a particular line.

Class G, an engineer who does some contracting and fills in his time practicing engineering.

Cost of Engineering Education.—It might seem proper at this time to discuss somewhat the cost of an engineering education because this is the foundation for a lasting superstructure of engineering practice. Considering that the cost of a college education is $500 per year and that some classes of engineers would require a four year course and some six years, some engineers would acquire a larger part of their education from their personal ability to study out problems in their own way. Really when you consider education in engineering, the practical education is the important part. Billy Sunday's diagnosis of an educated man is a man who knows a little and knows where to get what he wants when he wants it and knows how to use what he gets when he gets it. So the factor of education would fluctuate in that it would depend upon a man's ability to practically apply his knowledge before it could be ascertained what the value was of that knowledge to his business. In general, however:

Class A would require [illegible] $1,000.
Class B would require [illegible] $1,500.
Class C would require [illegible] $2,000.
Class D would [illegible]
Class E would [illegible]
Class F would [illegible]
Class G would [illegible]

It has been computed that 25 per cent of their time is all that classes D and E could devote to practice because of other duties. In considering practical experience, a 5 year period has been used.

NECESSARY EQUIPMENT

Class A, tools and fixtures, transportation facilities	[illegible]
Class B, tools and fixtures, transportation facilities	2,000
Class C, tools and fixtures, transportation facilities	1,500
Class D, tools and fixtures, transportation facilities	3,000
Class E, tools and fixtures, transportation facilities	1,000
Class F, tools and fixtures, transportation facilities	2,000
Class G, tools and fixtures, transportation facilities	3,000

Continuance of Business.—Ordinarily, the first year of Class A's time furnishes him 50 to 70 per cent employment;

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*Paper presented at last annual meeting of the Iowa Engineering Society, held at Des Moines, Iowa, Jan. 18-20.

second year 60 to 80 per cent employment; third year full time. After the third year, he usually enters into Class B and continues with 50 per cent assistants the fourth year, 75 per cent assistants the fifth year, and full time assistants the sixth year. If he is successful and energetic and has the personality and natural ability he will enter the seventh year with more than one assistant and be in Class C. In the tenth year of practice he has good chances of operating three or four departments, if he is energetic.

It may be necessary some time during this career for him to enter Class D in order to fill in part time in some position or he may be side tracked into Class E for a time or permanently. There is also a chance of side tracking into Class G but very few engineers reach Class F until after long years of experience. Very often Class E starts in Class A and develops more rapidly, arriving usually in Class F after he has the business ability. It seemed necessary to discuss this question because these facts are the foundation for considering the cost factors in engineering practice and it almost seems as though any formula which might be created would consist almost wholly of variables and a very few constants. In solving for X, which would represent the income of the various classes, only general statements can be made which would be modified by the various conditions entered into.

Items in Engineering Practice: It can be said, however, that there are items which enter into almost every practice which might be enumerated as follows:

Promotion Expense: This item covers the expense of promoting jobs, dues to associations, etc. It is necessary for the engineer to keep up with the times in order that he can better serve his clients just the same as any lawyer, dentist, or doctor, who is a professional man, must acquaint himself with the newest ideas. He must, also, watch the change of personnel of different bodies of men and keep them in touch with his qualifications in the work he is doing in order that the best interests of his business might be perpetuated.

Bonds: This item represents the cost of surety bonds which amounts to 1 per cent of the penalty of the bond or 1 per cent of the bond required. As the amount of the bond furnished is fixed by the parties requiring the bond, this is an indefinite expenditure. The amount of the bond is paid by the engineer and is an item of expense.

Insurance: This item represents the cost of working men's compensation which is compulsory under the Iowa State Law. It is 71 ct. per hundred for surveyors, 9 per cent per hundred for draftsmen, 2½ per cent per hundred for engineers on tile ditches, $3.75 per hundred for engineers on floating dredge work, $3.45 per hundred for engineers on suction dredges and other classes. This item fluctuates from time to time.

Traveling Expense: This item represents the expense of traveling to jobs you do not get and the visiting to jobs under construction in order to ascertain information. There are many trips necessary in order to get final settlement on the work after it is completed. This, also, includes expenses to society meetings in order to keep up with the times.

War Tax: This item must be an item on all costs as it represents the tax not only on profits but also on telephone, telegraph, and express bills.

Interest on Investment: This item must be a part of all estimates of cost amounting at present to 7 per cent.

Interest on Jobs: This is not interest on investment but interest only on money borrowed to carry on jobs during the process of the work. That is, engineers must receive their wages and expenses must be paid regardless of whether or not collections are made. Very few assistant engineers have enough money to wait until preliminary expense is paid. Again, a great many warrants must be discounted from 1 to 4 per cent dependent upon the credit of the project before the banks will cash them, because the banks have to hold these warrants until the bond issue is put through. Many warrants are marked "Not Paid for Lack of Funds."

Discount: As mentioned above it is necessary some times to discount warrants and hold bills between board meetings. Some times one cannot cash these warrants for several years.

Job Expense: This item includes miscellaneous transportation of men, expense of lost time for men who receive steady pay, storage, job office rent, etc.

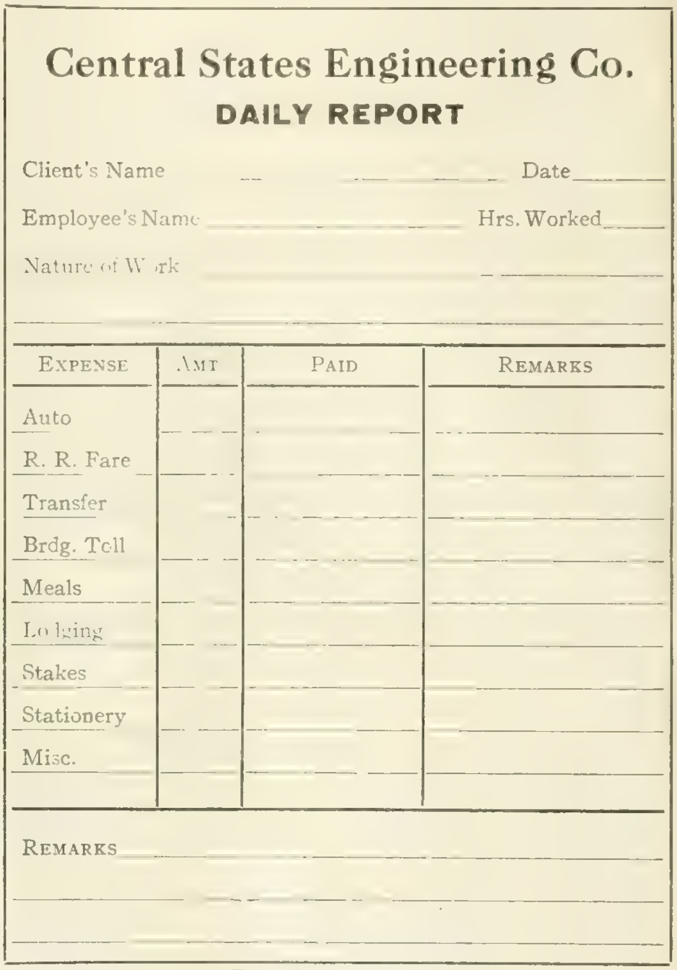
Repairs: This includes the cost of repairs to tools and equipment and tools lost or stolen.

Depreciation: Every engineer has depreciation on his equipment which amounts to 10 per cent per annum on the cost of equipment. In some cases this should be doubled.

Risk: This factor is indeterminate. Sometimes during preliminary surveys the bills are not paid. The preliminary bond sometimes is insufficient or the work is held up by legal procedure so as to be detrimental to the engineer's pay. The money must ofttimes be borrowed for an indefinite time to carry on business and discounts. Fees for testimony at $1.35 to $4.00 per day can be enforced by law.

Office Expense: This item represents stenographer, rent, light, heat, janitor, postage, telephone, telegraph, control systems, books, supplies, advertising and expenses of like nature which every business must pay.

Salaries: This question of salaries would be a local one and be easily determined by a summation of the salaries paid during the year but it is hard to anticipate just what salaries should be paid on any particular job because of the fluctuation of the other factors involved. One can only draw general conclusions after a definite experience in a particular locality and after a careful computation of costs and the various factors involved, before he can determine what is a fair amount to pay in salaries. It is often hard to tell until several months into the next year's business what the profit of the business is, until all the collections have been made for the previous year up to January first. Sometimes accounts of one year will not be paid for months after the year's work has been completed. Therefore, the determination of profit cannot definitely be ascertained until one knows whether or not he had any bad accounts. Many a business has failed not because the profit was not in the procedure of the work but because the accounts of the business could not be collected.



Central States Engineering Co.

DAILY REPORT

Client's Name ______ Date ______

Employee's Name ______ Hrs. Worked ______

Nature of Work ______

Expense	Amt	Paid	Remarks
Auto			
R. R. Fare			
Transfer			
Brdg. Toll			
Meals			
Lodging			
Stakes			
Stationery			
Misc.			

Remarks ______

Form for Job Report.

Method of Cost Keeping.—The method of cost keeping which we have adopted is to make out a ticket in duplicate for each job performed each day. We file one of these tickets under the client's name and one ticket under the employees name. From these tickets under the employees name we make up his salary and from the tickets under the client's name we make up the client's bill, which may consist of the work of several men. These tickets are 3 in. by 5 in. and can be filed away in an ordinary 3 in. by 5 in. card index box. They are made up in little books, 50 to a book, and each man makes out his own ticket. Below is a copy of the form which we use.

In transferring this item to the client's bill it is itemized in columns of Chief Engineer, Assistant Engineer, etc., as shown in copy of form below.

CENTRAL STATES ENGINEERING CO.
OF MUSCATINE, IOWA

IN ACCOUNT WITH

YEAR MONTH	Date		Chief Engineer	Asst Engineer	Draughtsman	Field Helper	Transportation	Meals Lodging	Miscellaneous	TOTAL

Form for Itemizing Cost of Work; Actual Size, 5 In. by 8 In.

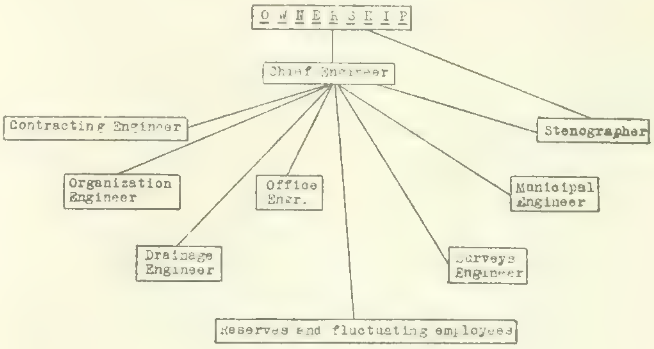
No material is secured without an order and this keeps the amount of materials purchased on the stubs of our order book. This way, we are able to keep an itemized account of every transaction and every item whether it be transportation, time on promotion, traveling expenses or any of the items above enumerated.

One factor that is indeterminate but must be taken into account is the loyalty of the employee and his abidance by the ethics of the profession. Ofttimes this item is very large when one has to keep training men over and over again to fill the different departments of the work. While it is always a source of gratification to see one's employees advance there ofttimes becomes a limit to the amount of salary that can be profitably paid. Ofttimes one year is a good year and another year is a bad year, so that the cost of doing business would fluctuate with business conditions and the employee not having the facts at hand might jump at conclusions and often attempt to supplant the employer after he had been nursed and fed to a healthy condition by a well meaning parent. As a usual thing, this class of employee receives the same treatment when, in later years, he fills the shoes of his employer.

Profit Sharing Plan.—Whether or not the employer would receive an apportionment of the profit would depend upon his loyalty, his attention to business and the success of his work, and the class of service the engineer performed. And again it would depend upon the value of business over a period of years, taking the good years with the bad years, the successful collections of accounts, and the education of clients. This factor of education of clients would fluctuate greatly with the need for the same. However, any business needs to educate its clients. Very few clients understand the functions of an engineer because they would almost need to be engineers themselves in order to realize what is necessary to produce certain results. The clients of an engineer are just like any ordinary man who goes to our legislature. They cannot be expected to be versed in every question from the boll-weevil to the flying machine but they must inform themselves upon various subjects in order to determine their course in voting. Likewise, if an engineer does not give his clients a conception of engineering service, then he cannot expect much business. It is my opinion that the education of clients is one of the largest factors of cost which enters into the engineering practice.

Organization Outlines.—Engineers operating in Class C, especially, must devise some operating plan or method of operation and feed it down to the different departments in some systematic method. There is a cost factor here, then, of devising ways and means to economically transmit the responsibility to the various departments. Quite a bit of money can be saved clients where men in different departments are experienced and advanced in a particular class of work, thus rendering competent service which could not be otherwise rendered by one engineer who would not be versed in all kinds of engineering business. This factor, then, would aid in the economic carrying out of a project of larger magnitude. We are showing below an organization outline which might be a factor in successful operation, consequently a factor of cost.

Summary.—An attempt has been made in the above discussion to present the factors of cost in order that any engineer in business might apply these factors of a cost keeping system and thus over a period of years localize different cost factors to the class of business which he performs and to the community in which he operates. An attempt has also been made in the table to set out as nearly as possible the separation of cost factors encountered in each class of business enumerated above. It is needless to say that it was necessary to estimate a number of these factors but with the factors at hand any engineer will be able to fill in his own table and to recognize that such factors exist if he has not previously realized it. Some of the factors may not be involved in some classes of business but the engineer in practice can select those factors which are applicable to his particular class and ultimately arrive at his own conclusions. It has been recognized that the reason why computations vary in engineering lines is because engineers do not operate on the same basis and do not perform the same service for a given price. Engineers do not all have the same will power to put projects across under adverse conditions. So the percentage of "I WILL DO IT" which a



Organization Outline.

TABLE SHOWING COST OF ENGINEERING EDUCATION, CAPITAL REQUIRED AND TOTAL AMOUNT OF BUSINESS.

	Cost of an engineering education.			Necessary capital			
Class of service.	Four years.	Six years	Five years' practical.	Necessary equipment	Money in accounts.	Total necessary capital.	Total amount of business, including wages and expenses.
A	$2,000		$1,000	$2,000	$2,000	$4,000	$4,500
B	2,000		1,500	3,000	4,000	7,000	6,500
C	2,000		3,000	8,000	12,000	20,000	30,000
D	2,000		5,000	2,000	2,000	4,000	1,200
E	...	3,000	1,000	1,000	1,000	2,000	1,500
F		3,000	3,000	2,000	2,000	4,000	6,500
G	2,000		2,000	3,000	4,000	7,000	2,000

25 per cent of time for D. and E considered available.

TA[illegible]LE SHOWING COST ITEMS [illegible] ENGINEERING [illegible]

This table [illegible] own [illegible] the problem [illegible] varies [illegible] in different [illegible] is worked out for the purpose of [illegible] all the items of cost.

Item	A	B	C	D	E	F	G
[illegible]							
[illegible]							
Lost Time							
Personality							
Natural Ability							
Personal Application							
Efficiency							
Promotion							
Bonds							
[illegible]							
Fire Insurance							
Life Insurance for Business Sec[illegible]							
[illegible] Get							
Traveling Expense on Jobs [illegible]							
[illegible] Meetings and [illegible]							
War Tax							
[illegible]							
Interest on Jobs							
[illegible]		6					
[illegible]							6
[illegible]							
[illegible]							
[illegible]							
Stenographer							
[illegible]							
[illegible]							
[illegible]							
Janitor							
[illegible]							
Telephone							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
Advertising							
[illegible]							
Salaries							
Cost Keeping Systems							
Bonus							
Collections							
Organization Outlines							
Training of New Employes							
Education of Clients							
Personal Improvement and Education							

man possesses would be a factor in the cost. This is a larger factor than might be anticipated at first sight. It has been said, that if all engineers engaged their services on the same basis that ultimately the engineering profession would receive what it is justly entitled to for services rendered and the clients would better understand what they were receiving for the price they paid. The existence of this condition has caused the writer to attempt to analyze cost factors in order that a basis for standardization could be arrived at with a view to rendering some small service to the engineering profession as a whole and to the general public as well.

Service Department A. A. E. Finds Jobs for 3,243 Engineers in 1920.—Three thousand, two hundred and forty-three engineers were placed in positions during 1920 by the Service Department of the American Association of Engineers, according to a report just issued by that department. This number of men placed is the number for which records were actually received showing that positions were filled and does not include very many positions which were undoubtedly filled but for which reports of placement were not made by the employer or the employee. The Service Department handled 7,617 positions during 1920, filling about half of them; 35,254 references to positions were made to individual members of the association in the course of the year. The total annual salary for all the positions filled during the year was about $8,500,000. The lowest salary paid by any position filled was $125 a month. The highest salaried position was $15,000 per annum. The average salary of positions filled was in the neighborhood of $200 a month.

How to Secure Best Results in Constructing Concrete Floors for Foundries

Methods of constructing concrete floors for foundries were described by Mr. H. C. Boyden of the Portland Cement Association in a paper presented last fall at the annual meeting of the American Foundrymen's Association. An abstract of the paper follows:

In general the floor should not be less than 5 in. thick, and in foundries making heavy castings the thickness should be 7 in. Concrete with a compressive strength of 3,000 to 5,000 lb. per square inch can readily be made if a few simple but important rules are followed. The first is that an analysis should be made of the aggregate—sand and pebbles or broken stone—that is to be used, and the proportions that will give the greatest strength be determined and adopted. There is only one such proportion for each aggregate and it can readily be found. "Abrams' Table of Proportions and Quantities" has recently been published and gives full information on this point.*

The second rule is to use just as little water in mixing the concrete as possible, and at the same time have a workable, plastic mixture. Up to a certain point the compressive strength of concrete increases as the water ratio decreases, and the limiting water ratio is considerably below the ratio required to give a workable, plastic mixture. The water ratio is always figured as gallons of water to one sack of cement.

The proper water ratio varies for different aggregates and mixtures so that it must be determined for each case. To determine it a simple test, called the "slump test," has been devised. A frustum of a cone 4 in. in diameter at the top, 8 in. in diameter at the bottom and 12 in. high, made of sheet metal, is filled with the concrete to be tested, which is placed in the casing in layers, and carefully worked with an iron rod while being placed. The casing is immediately lifted off and the settlement or "slump" is measured. For a foundry floor the proper slump is between 1 in. and 1½ in. A greater slump indicates the use of too much water.

As a guide in determining the proper amounts of water to be used the following approximation may be useful: With a 1:2:4 mixture use 6 to 6½ gal. of water for each sack of cement; for a 1:2:3 mixture use 5¾ to 6¼ gal., and for a 1:1½:3 mixture, use 5½ to 6 gal.

The third rule is to mix the concrete thoroughly; if a mechanical mixer is used, it should be turned at least one minute after all the ingredients, including the water, have been placed in the drum. If the concrete is mixed by hand, it should be turned at least five times on the mixing platform. Machine mixing is advisable because of the uniformity of the product thus secured.

For a foundry, a concrete floor should be built in one course and should either be continuous or in sections without expansion joints, except that if desired, joints may be made next to the building walls. If the building is divided into bays by columns, each section may cover an entire bay; the floor can be laid in alternate bays and the omitted bays filled in after the first ones have hardened.

The floor should not be troweled with a steel trowel, but should be rolled with a steel roller 8 or 10 in. in diameter, about 6 ft. long, and weighing about 100 lb. This rolling will add greatly to the strength of the floor by squeezing out any excess water, thereby reducing the water ratio. Suitable protection for the floor during its early hardening period should be provided, as this greatly influences the compressive strength and resistance to wear.

In order to attain its maximum strength and hardness a concrete floor must be kept warm and damp during this period. Covering a concrete floor with damp sand, as soon as it has hardened sufficiently, and keeping it damp by frequent sprinkling for the first 10 days will increase its compressive strength over 75 per cent and its resistance to wear over 40 per cent. Still better results will be secured if this protection can be continued for three weeks. It is best not to use the floor until four weeks after it is laid.

The question of whether the surface of the floor will spall when molten metal is spilled upon it is not serious. It would be well, however, to avoid the use of granite or quartz gravel aggregates in the construction of such floors, because those materials do not stand heat as well as certain other aggregates. Trap rock possibly makes the best aggregate for resisting heat, and slag, limestone, or limestone gravel may be used with excellent results.

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*See Engineering and Contracting, May 5, 1920.

Hot metal where spilled on a concrete floor will not pop unless the floor is wet or the concrete contains moisture. A concrete floor can become moist in only two ways: First from water spilled on the surface, and second by absorbing water from the ground beneath. The spilling of water on the floor surface is under the control of the shop foreman and of the molders themselves, and the results, viz., the popping of spilled metal, will be the same no matter what type of floor is used. The second cause of moisture in a concrete floor, absorption from the sub-base, can be avoided by properly draining the sub-base and spreading a few inches of porous gravel, cinders or other suitable material over the ground before laying the floor. Furthermore, if the concrete is properly made, it will be watertight and will not absorb water in this manner.

Comments on Construction of Dry Kilns

Any of the ordinary building materials—wood, brick, tile, or concrete—may be used in the construction of a dry kiln. The choice between them will depend upon the relative importance of the first cost, maintenance, and fire hazard. The following comments on each type are based on the experience of the U. S. Forest Products Laboratory.

Where insurance rates permit, a well-built wood kiln is very satisfactory, wood being a very good insulator, easily repaired, and cheaper than the other materials. The chief objection to the use of wood, aside from fire risk, is its tendency to swell and shrink with alternate moist and dry conditions, causing more or less working of the frame and loosening of nails. All lumber should be thoroughly seasoned. Fir, Douglas fir, yellow pine, redwood, cypress, and similar woods with low shrinkage rates should be used for sheathing and sills. For frame timbers any good straight-grained material is suitable. The sheathing should be shiplap laid horizontally and nailed twice at each stud, in the middle and at the bottom of the board. Outside walls should be sheathed on both sides or sheathed inside and plastered outside. They should also be insulated with a good moisture-proof, heat-resistant insulator. The ordinary quilt insulations sewed between so-called waterproof paper have not proved satisfactory in dry kiln construction. Walls should be painted on the inside with asphaltic paint. Where lumber is plentiful, crib or laminated construction may be used, the walls being built up of 2 by 6-in. planks laid flat, and the roof of similar material laid tight together. If the planks are well seasoned and well manufactured, this form of construction permits very little heat loss; but if the lumber is low grade and knotty, a tight, weather-resistant construction is extremely difficult to obtain. The shrinkage of the walls is excessive, and causes considerable trouble at door jambs and where pipes pass through the walls.

Brick or hollow tile is procurable almost everywhere, and where permanency is desired is usually more satisfactory than wood. The brick or tile should be hard burned. The walls should be laid up in tempered or cement mortar. Unequal expansion in the exterior walls, caused by the difference in temperature of the outer and inner faces, is almost certain to create numerous small cracks, which should be painted up with an elastic cement rather than mortar. A kind of tile should be chosen that has openings running horizontally rather than vertically in the wall. The tile should be scored for plastering. Both sides of tile walls should be plastered with cement mortar. When brick, tile, or concrete kilns are over 50 ft. long, it is advisable to build both the exterior and interior walls 12 in. thick, particularly if fireproof roofs are used.

Walls of monolithic concrete or of concrete blocks are highly absorbent of moisture unless thoroughly waterproofed. It is very difficult to hold a high humidity within a kiln whose walls absorb moisture readily. The heat loss through such walls is also very great.

Organized Labors' Experiment in Cooperative Building*

By BERNARD PETERSON.

Through the recent formation of the Building Trades Unions' Construction and Housing Council organized labor in Boston has entered the field of general contracting, with the purpose of establishing itself as a real factor in the campaign to speed up the production of houses to relieve the present shortage.

Essentially a labor organization, this council departs in several respects from the old line of unionism. In its underlying principles the council expresses the aversion of the trade unions which organized it, for the "direct action" policy with which the structural unions so frequently have been charged. In its form of organization the council takes pains to steer clear of strikes, lockouts, injunctions and entangling alliances that might interrupt its work. In its charter provisions it recognizes the disadvantages of dealing with labor unions that are not incorporated, and stipulates that inasmuch as the unions generally are not incorporated, no paid officials of any labor union shall hold office in the Building Trades Unions' Construction and Housing Council. The council itself is incorporated and assumes the legal responsibilities of a corporation; it therefore does not want to involve its affairs in the influence and actions of bodies that are not incorporated.

Now equipped with a charter, which it received on October 4, 1920, a complete set of officers, a committee on financing that has plans already developed for a co-operative bank, a staff of engineers and architects and approximately 600 shareholders, it is ready to go to work. In fact it has undertaken one job already and has almost completed its first house.

How the Council Was Organized.—The prospective scope of this movement in Boston will be better understood when it is known how the movement started a few months ago. Its leaders today say that they were actuated in the first instance by a desire to vindicate their craft against the general accusation that it was a destructive force, aiming in revenge at the blowing up of buildings and bridges. They smarted under these accusations and wanted to prove to the community that they not only are a peaceful class of workmen, but endowed with intelligence and experience to undertake the whole job of financing, managing and building. Hence all the building trades unions in Greater Boston were invited to send five delegates each to a conference a few months ago. Only plain working men, who earned their livings with their hands and tools in the various lines of building activities, and no union officials or any representatives of unions drawing salaries from the unions were invited. The 165 workmen so assembled formed the Building Trades Unions' Construction and Housing Council. They applied for a charter, and on October 4 secured a Massachusetts charter that is so broad in its scope that it permits the council to go into general contracting, lend money, deal in building material and real estate, and go into almost any kind of business it might desire. The corporation is capitalized at $100,000, divided into shares of $10 each, but no shareholder can buy more than ten shares. Up to October 25, or when the corporation was twenty days old, it had sold shares for $6,570, representing close to 600 subscribers. As soon as it is ready to begin on its financial campaign, its officers believe they can easily raise all the money they want, because there are approximately 42,000 union men in the building trades whose thirty-three locals are all represented in the co-operative council, in addition to 50,000 other union men affiliated with labor organizations in Greater Boston. If each of the union men buys one share each and pays for it at the rate of $1 a week for ten weeks, a large building fund would soon be raised.

Solving the Problem of Finance.—The next move planned is the organization of a co-operative bank to become the depository of their funds. By means of this co-operative bank the Co-operative Council proposes to finance the building of homes for members or outsiders, the bank taking the first mortgage. Under the state law, a bank may lend up to about 80 per cent of the value of real estate, and if the co-operative method of building keeps the cost substantially below the current market value of the house, it is expected that the 80 per cent of the value will go a long way toward covering the total cost. The owner also will put money into the house, and the co-operative council will take a second mortgage for the difference between the cost and the loan obtained from the bank plus the owner's cash on hand. In this way the co-operative council expects to make the financing of a house sufficiently easy to stimulate the building of homes among the workmen.

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*From the January Bulletin of the Associated General Contractors.

Settling Materials and Labor at the Source.—At present the council goes into the open market to buy material. It had to do that for the first house it started, and expects to have to do it for the jobs on which it is figuring at present, but it is planning also on a co-operative brick yard, a co-operative gravel pit, co-operative lumber yards, and a gradual expansion of this co-operative idea to include all the building materials that it can conveniently finance.

Union wages are to be paid and union conditions observed, but there can be no strike on the job, or any lockout, and the job cannot become involved in any injunctions proceedings that might be brought against the labor unions, since no paid union officials are connected with the council. For, while the co-operative movement is one of union men, it is not a labor union in itself, but a corporation.

Having control of the union labor within the building crafts to command as it wishes, the council figures on its ability to furnish sufficient workers in each case to construct each home quickly and economically, with the minimum loss of time. The officers admit that they are not yet trained in the necessary office work such as bookkeeping, typewriting and accounting, but they can command the service of experts in those lines, too, since there are unions to call upon for assistance. Moreover, the council is taking full advantage of the expert advice it can get from Harvard University, Wellesley College and from lawyers in Boston, whose generous helpfulness in starting the movement right the council acknowledges. Besides this a large number of members of the council are taking courses in banking and accounting, architecture, blue printing, etc., at the Trade Union College in Boston to equip themselves for the "office" work of this co-operative building movement.

How a Job Is Handled.—How does this Building Trades Unions' Construction and Housing Council propose to handle a job? It gets a prospect. Presumably it is a union man who wants to build a house. In fact, the job it is figuring on now is a home for a working man whose family has almost enough money to cover the cost. This job is taken up for discussion in the council meeting, at which there is a mason, a carpenter, a bricklayer, a plumber, a glazier, a plasterer and others present familiar with the practical work. There is also an architect present who works for the council. The representatives of each specific craft involved are asked to estimate the cost of their part of the work, and then all the estimates are gone over by a final authority, summed up and a bid submitted. If the job is awarded to the council, one of the members is designated to take general charge of the work, and as the work progresses he will call a practical workman from the various crafts to supervise the carpenter work and the bricklaying, etc., paying such foreman the wages he would receive if engaged for a similar position by a general contractor. During the progress of the work the general foreman will be in consultation with the owner, permitting any changes in the plans that the owner may desire.

The actual operation of this novel plan of co-operation on its first job is significant. When it undertook the construction of this house the council was not in a position to finance the job as a contractor would, so the owner financed it himself. Consequently the council submitted its estimate of cost, which is reported to be practically 30 per cent under the going market, and it secured the job. It was then agreed between the council and the owner that the owner, watching the process of construction, should have the privilege of introducing any element of saving by substitution of material or change of plans, and when the house is completed the owner should pay the council a certain percentage on the actual cost. Within three weeks the council had the roof on the house, and by Christmas the house will be ready for occupancy. Present indications are that the actual cost will be well under the council's estimated cost.

The Underlying Purpose.—Until the council has had a little more experience it cannot decide upon a fixed percentage of cost as its own compensation, but John F. Nason, its president, says that its purpose is to fix by experimenting a definite margin that shall constitute the council's compensation for supervising the construction of a house. He says that this margin will be equivalent to one contractor's fair profit, based on actual cost, and will save the owner the several profits that go to subcontractors under the ordinary method of construction. With that saving the council hopes to appeal to a somewhat restricted class of customers, aiming in the first instance to stimulate house-building and house-owning among the workmen themselves and always to keep out of the speculative real estate market.

In its many ramifications the plan is a composite of the numerous plans that have been suggested in various parts of this country and in England, the result of a long study. The leaders claim that it is wholly different from anything that has been undertaken before in the United States. Operations under it will be confined to Boston and the few cities and towns in the immediate vicinity. New York has, however, inquired into the Boston plan and Worcester is said to be contemplating the formation of a council.

Prices of Bridge and Culvert Materials in Iowa in 1920

The following tables from the December issue of the Service Bulletin of the Iowa State Highway Commission show the range of prices for various bridges and culvert materials during the 1920 construction season. The figures were obtained from the records of the Bridge Department of the Commission and cover the season up to Dec. 1:

CORRUGATED CULVERTS.

Price per lin. ft., f. o. b. County.

Class A.			Class B		
Size.	Range in price.	Avg.	Size.	Range in price.	Avg
12 in.	$0.90 to $1.08	$0.99	12 in.	$0.83 to $0.98	$0.93
15 in.	1.21 to 1.65	1.51	15 in.	1.25 to 1.56	1.43
18 in.	1.45 to 1.90	1.71	18 in.	1.50 to 1.80	1.68
24 in.	2.05 to 2.43	2.39	24 in.	2.00 to 2.60	2.27
30 in.	3.45 to 4.35	4.18	30 in.	3.25 to 4.20	3.80
36 in.	4.14 to 5.40	4.92	36 in.	3.75 to 5.02	4.69

LUMBER—Price per M f. o. b. County.

Size.	Descr.	Range in price.	Avg.	Size.	Descr.	Range in price.	Avg.
3x12	S S Fir	$45 to $55	$51.10	3x12	F S. Fir	$46 to $60	$50.25
3x14	S S Fir	50 to 60	54.00	3x14	F S. Fir	50 to 62	53.40
3x16	S S Fir	51 to 60	54.20	3x16	F S Fir	51 to 64	55.60

STRUCTURAL STEEL.

Trusses.			I-Beam.		
Descr.	Range in price.	Avg.	Descr.	Range in price.	Avg.
F. o. b. Co.	$7 to $9.00	$7.63	F. o. b. Co.	$5.65 to $6.90	$6.13
Erected	9 to 12.50	10.80	Erected	7.00 to 9.00	7.55

PILING.

Red Cedar.			Cypress.		
Size.	Range in price.	Avg.	Size.	Range in price.	Avg.
16 in.	$0.30 to $0.46	$0.346	16 in.	$0.18 to $0.40	$0.283
20 in.	.32 to .48	.373	20 in.	.28 to .40	.297
24 in.	.33 to .55	.402	24 in.	.31 to .45	.329

During 1920 the dealers net price per bbl. of cement f. o. b. Cedar Rapids in car load lots has ranged from $2.71 with an average price of $2.39.

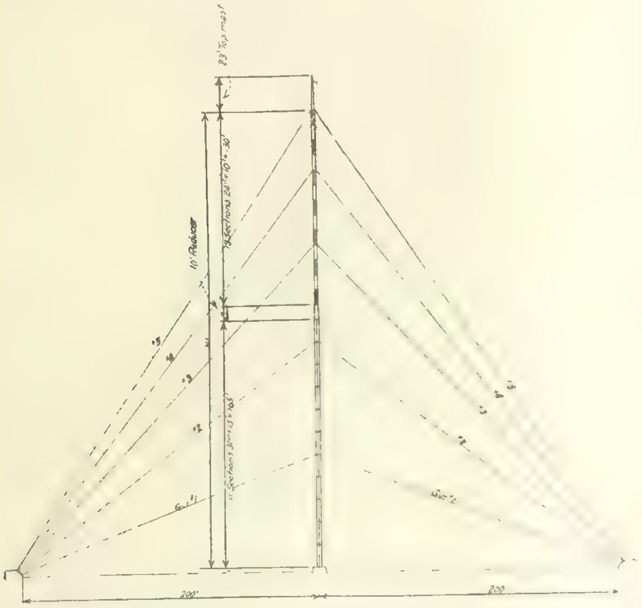
One-half inch reinforcing bars have ranged in price from $4.10 per cwt. to $5.38 with an average price for the year of $4.90. Three quarter inch bars have ranged from $4.12 per cwt. to $5.25 with an average for the year of $4.82.

Arkansas Engineering Society to Join A. A. E.—The Arkansas Engineering Society voted unanimously on Jan. 17 to make application for a charter as a chapter of the American Association of Engineers. The vote was taken at the annual meeting held in Little Rock. The society is asking for jurisdiction over the state of Arkansas with the exception of student chapters. The Arkansas Society includes members from all over the state of Arkansas and is the only state organization of engineers in that state. It is about the eleventh society of engineers to amalgamate with the association; others have been the Oregon Society of Engineers, Engineers' and Architects' Association of Southern California, Southwestern Society of Engineers, Navy Technical Association, North Carolina Engineers' Society, Michigan Engineering Society, Northwest Society of Highway Engineers, Idaho Society of Engineers, and the Engineers' Club of Kansas City.

Light Mobile Equipment Used in Construction of Mast Foundations for Radio Station

The construction of mast foundations at the Tuckerton station of the Radio Corporation of America presented a difficult situation which was overcome by the use of light, mobile equipment.

The station is situated on the Jersey Meadows about 6 miles from Tuckerton, N. J., and was originally built for the German Government. Since coming into possession of the Radio Corporation of America after the war a decision was reached to increase its capacity, and a contract was accordingly awarded to The J. G. White Engineering Corporation to erect six steel masts, each 305 ft. high.



Arrangement of 305 Ft. Steel Mast and Guys at Radio Station, Tuckerton, N. J.

The foundations for these masts were excavated in swampy material, which necessitated sinking coffer dams to a depth of 8 to 10 feet for each of the 6 masts and 24 anchorages. On account of the poor bearing quality of the soil it was found necessary to drive piling in each coffer dam.

As the ground was not able to sustain heavy plant it was deemed expedient to design a special rig for driving these piles. This was accomplished by equipping a light pile driver with a gasoline hoist and supplementing it with gasoline-operated jetting equipment of sufficient power to insure penetration of the piling to the desired depth.

Concreting Anchors Using Belt Conveyor for Raising Concrete to Necessary Elevation.

This same situation presented a problem in concreting the foundations and in distributing sand, gravel, cement and lumber, as well as steel for the masts. A unit consisting of one mast and four anchorages required approximately 250 yd. of concrete, making an average of 50 cu. yd. for each individual pour.

After a careful study of the situation there was employed for material distribution two Fordson tractors especially equipped with an extension to the traction wheel to afford as wide a bearing as possible. Each tractor was coupled to an ordinary light gravel wagon of the stick-box type equipped with extra wide tires. These were able to travel on the meadows in any direction and operated in a most economical manner.

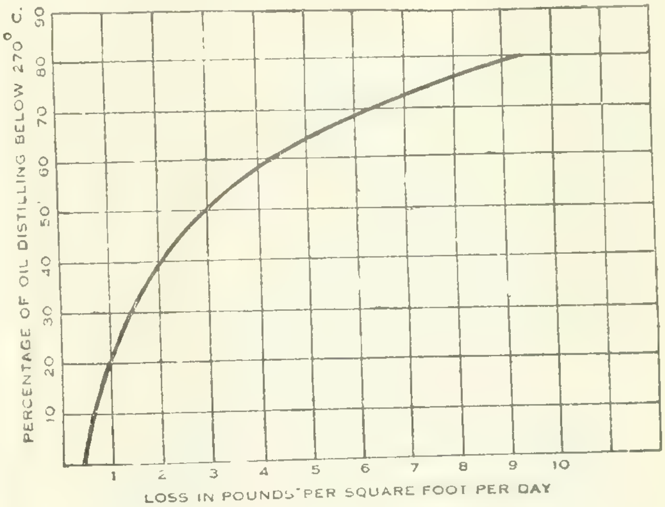
It was necessary to the design of the foundations to have them extend above the elevation of the ground from 8 to 10 ft. To pour this concrete it was decided to use Koehring "Dandy" one-batch mixers operating in conjunction with style "B" 30 ft. belt conveyors manufactured by the Barber-Greene Co. This equipment which is shown in the illustration is light and can be easily and quickly moved. The conveyors proved entirely satisfactory for raising the concrete to the necessary elevation that would permit of a distribution by chutes into the forms. The concrete was admitted to the conveyor through a wooden hopper having an opening directly over the belt which allowed a discharge without scattering the material and a delivery without waste. It was found necessary to place a wiper made of belting or rope on the top of the chute under the conveyor in order to keep the belt clean.

Loss of Creosote By Evaporation From Open Tanks

The amount of creosote lost through evaporation in open tank treatments has been shown in experiments at the Forest Products Laboratory to be in proportion to the area of the exposed surface and the volatility of the oil. At the treating temperature of 195° F., the loss of creosote in pounds per square foot per day may be computed from the equation,

$$\text{Log } L = .0165\ V - .347$$

in which L is the loss in pounds per square foot of exposed surface, and V the percentage of the creosote distilling below 270° C. Or the loss may be found without computation from the curve of this equation given below.



Curve Showing Loss of Creosote by Evaporation.

The equation and curve given here are applicable only when the temperature of the treating bath is in the neighborhood of 195° F. At higher and lower temperatures, constants other than .0165 and .347 should be used, and these constants have not yet been determined.

Engineers' License Bill Contains Reciprocity Clause.—At its regular monthly meeting Jan. 14, the Boston Chapter of the American Association of Engineers approved the revised bill as drawn up by the Legislative Committee of the chapter for the registration of the professional engineers of the state of Massachusetts. One of the features of the bill is a provision to allow engineers of other states to practice in Massachusetts provided those states in turn allow Massachusetts engineers to practice in their states. The bill is now before the State Legislature.

General Contractors' Convention.—The annual convention of the Northwestern Association of General Contractors will be held in the St. Paul Hotel, St. Paul, Minn., March 11 and 12.

The Writing of Engineering Reports

Useful suggestions on the preparation of reports on engineering projects are given by Charles B. Breed, Professor of Railway and Highway Engineering at Massachusetts Institute of Technology, in the January Tech Engineering News. His article follows.

Report writing may be defined as the art of answering responsively the question assigned in such a manner as to compel the non-technical mind to comprehend the conclusion intended.

Lucid language is necessary to comprehension. The redundancy and incoherency of many modern authors is in sharp contrast to the simple language of the old classical writers. A study of the style of the letter will be profitable to the young engineer, whose college training in written work has been largely in preparing mathematical data in tabulated form for the approval of a professor who is familiar with the technicalities of the subject matter. An engineering report is usually made to a body of laymen. It therefore involves, first of all, a recognition of the limited technical knowledge of the reader, and then an attempt to place before that mind the results of technical work in the language familiar to the reader. Technical results and conclusions can usually be expressed in ordinary language and in concise form. It is not always so easy to express the details of the research leading up to the conclusions without the use of some technical terms.

Engineering reports are often made to a commission, an industrial executive committee, or to financiers. The report is made use of by these men to aid their judgment as to the business prudence of some project. The engineer's report is only one, though often a very essential element considered in determining the adoption or the abandonment of a proposition.

Report writing logically requires so broad a treatment that it is advisable to consider here only one general type of engineering report, namely, a report on the feasibility of a construction project. Such a report should be laid out as follows: First the title; this should appear on the outer face of the cover. It should contain the elements suggested in the following example.

Report upon
Feasibility and Cost of Construction
of
Black River Improvement
Made to
The Black River Chemical Co., Madison, Tenn.
by
James W. Towne,
Consulting Engineer
November 15, 1920.

The title is sometimes repeated on the first sheet of the report, but this is not necessary.

The next page should be the Table of Contents, which is obviously completed last, although it should be laid out at the start, as it forms the skeleton of the report.

Next comes the Letter of Transmittal, which is addressed to the official to whom the report is to be made, care being taken that the official's title is correctly given at the head of this letter. It is a brief letter stating that in compliance with directions received from him on a certain date this report is respectfully submitted; this letter is signed by the engineer.

The Directions under which the engineer is working then follow. This is an exact copy of the letter assigning the work to the engineer or it is a concise relation of the directions therein given. Its purpose is to acquaint the reader with the question which the report is to answer, since the reader is often not the one who actually wrote the letter of directions.

The Conclusions in Brief are then given. These will usually be stated in one or two pages of typewritten matter. This should be in the nature of a direct and responsive answer to all of the questions propounded in the letter of directions. Its purpose is to permit the reader to obtain the conclusions without laboriously wading through the entire report.

Next comes the Detailed Engineering Report. It may properly contain a statement of the existing data used and its dependability, surveys and investigations made, sources of information, projects considered but rejected, with the reasons for rejection, the design adopted, together with an analysis of its advantages and disadvantages, and finally the reasons for its adoption. This section comprises an analysis rather than a tabulation of the data.

Scientific data which are of little or no use to the non-technical mind should be put in Appendices at the end of the report. These will include tabulations of engineering results, data used as a basis for conclusions, report of specialists who have been called in to investigate a particular phase of the problem.

There can be no doubt that the psychological effect of an attractively bound and neatly typed report is favorable. But, while attractive appearance and logical presentation are necessary, the real value of any report lies in the accuracy of its facts and reliability of its conclusions.

Floating Oil as Protection of Concrete from Action of Sea Water

The covering of harbors and tidal rivers with refuse from the tanks of oil burning steamers is producing results which are the occasion of increasing protest. However, the somewhat unexpected outcome of the special concrete and sea water test by the Aberthaw Construction Co. at the Navy Yards, Charlestown, Mass., points to some value from the action of floating oil in protecting concrete surfaces between high tide and low.

In 1909 Aberthaw hung some twenty-four concrete piles —16 ft. long—under the cap-log of a wharf at the Navy Yard. The adjustment was such that the lower end of each pile would remain submerged at all tides, while the top would always rise above high water.

Various mixtures of various degrees of wetness were used in making the piles. Twice—in 1913 and again in 1920 —these piles were hauled out of their sea bath, carefully examined, and photographed. A report on the experiment was issued by Aberthaw in 1913. A new report, with reproductions of the previous and recent photographs, has just been printed by the company, and is ready for distribution.

Of the specimens examined, those which exemplified a rich, wet mixture appeared to be in the best condition. But the last examination has revealed a condition of the specimens which has not hitherto existed. One and all, they were coated from high-water mark to low with a thick, tenacious black substance, somewhat resembling tar, yet considerably less fluid when exposed to the sun. The substance varied in thickness from more than ¼ in. at high water mark to virtually nothing at low, and adhered so closely to the concrete that attempts to brush or scrape it off were entirely unsuccessful.

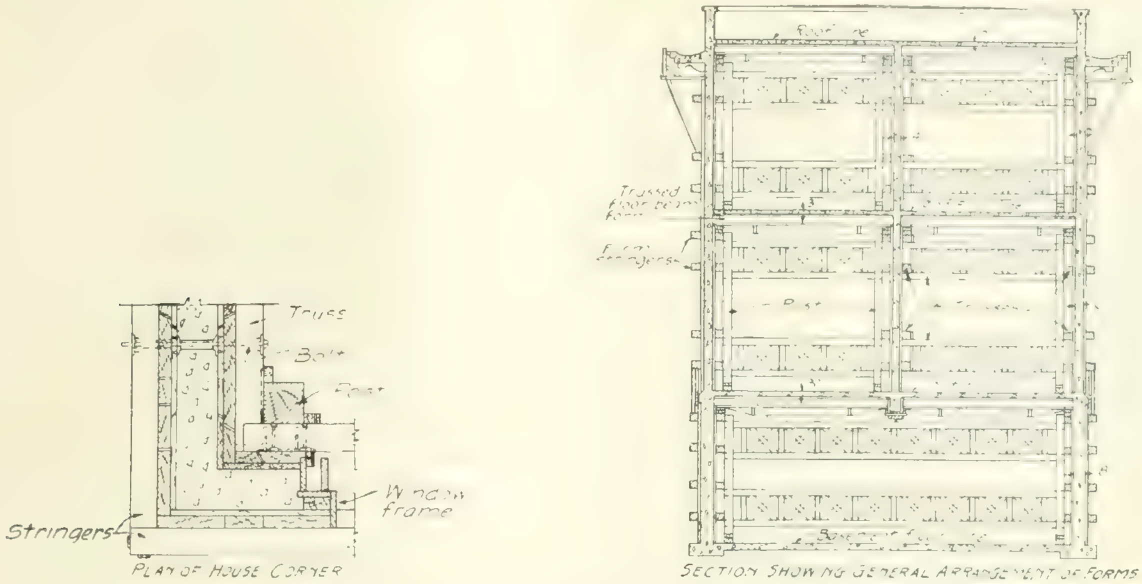
It was noticeable, further, that where this coating was adhering, barnacles and other forms of marine life which previous inspection had revealed clinging in profusion to the piles, were now completely eliminated. In so far as could be judged, further, erosion or corrosion had ceased with the advent of this coating, which, to all appearances, offers a complete protection to that part of the concrete surface which usually suffers from intermittent contact with salt water and the upper elements.

Investigation revealed the fact that the ships at the Navy Yard are using large quantities of fuel oil instead of coal, and that much of this material is constantly floating on the water, not only at the Navy Yard, but in all parts of Boston Harbor. Mr. G. W. Maker, who personally made the last inspection for the Aberthaw Construction Co., points out very particularly, however, that the substance adhering to the piles is not merely free oil. Somehow or other it has undergone a sea-change; perhaps only an emulsification together with an accompanying washing away of its lighter particles, but a change sufficient to make it a very perfect protection for concrete surfaces.

Chicago Building Trades Unions Want $1.25 Hourly Rate for Next 3 Years.—Business agents of 32 unions affiliated with Chicago Building Trades Council voted unanimously to resist any reduction from the present $1.25 hour wage for union building workers. They also voted in favor of continuing this hourly rate of pay for the next three years.

Concrete House Construction at Valley View Development of Ingersoll-Rand Co.

Like many other industrial concerns, the Ingersoll-Rand Co. at Phillipsburg, N. J., has for years been confronted with the problem of providing suitable homes for its employees and their families. As a start in solving this problem, a tract of land was acquired east of the plant, and the Phillipsburg Development Corporation was organized, with Paul R. Smith, Architect and Town Planner, in charge, to formulate plans for and handle the entire project. The development which resulted is known as Valley View.

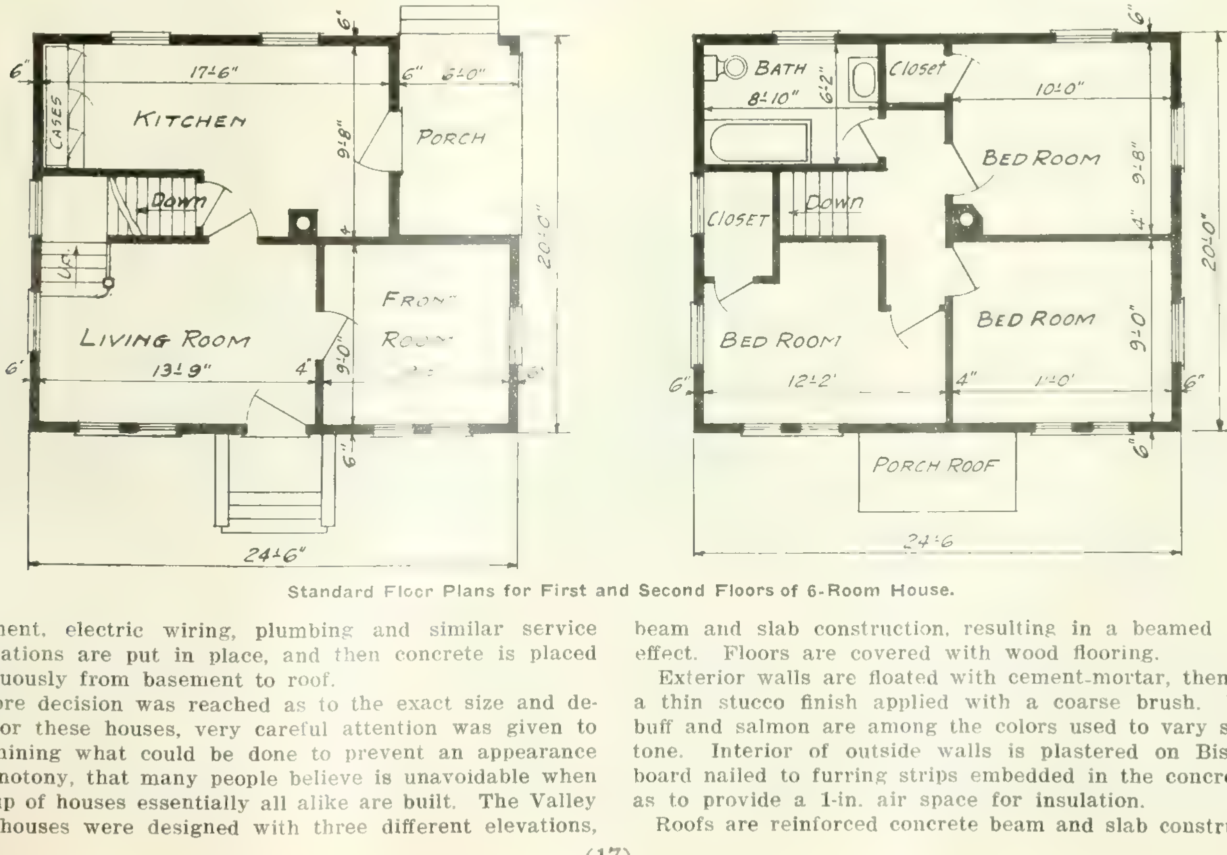


PLAN OF HOUSE CORNER

SECTION SHOWING GENERAL ARRANGEMENT OF FORMS

Details of Ingersoll Standard Forms.

The houses in the development are of concrete, built by the system of construction developed by C. H. Ingersoll of "dollar watch" fame, after ideas advanced several years ago by Thomas A. Edison. The forms used are of wood and are set up for a complete house at one operation. The reinforcement, electric wiring, plumbing and similar service installations are put in place, and then concrete is placed continuously from basement to roof.



Standard Floor Plans for First and Second Floors of 6-Room House.

Before decision was reached as to the exact size and design for these houses, very careful attention was given to determining what could be done to prevent an appearance of monotony, that many people believe is unavoidable when a group of houses essentially all alike are built. The Valley View houses were designed with three different elevations, so that their facing directions could be varied and thus present different street entrances.

The tract of land was laid out with winding instead of straight streets. The houses were set back from the sidewalk line and ample parking provided between sidewalk and street curb. Surface finish was varied by the use of several colors for the stucco coat, and window flower boxes, with shrubbery in the yards, helped to make up the outstanding features of an exceedingly attractive housing development.

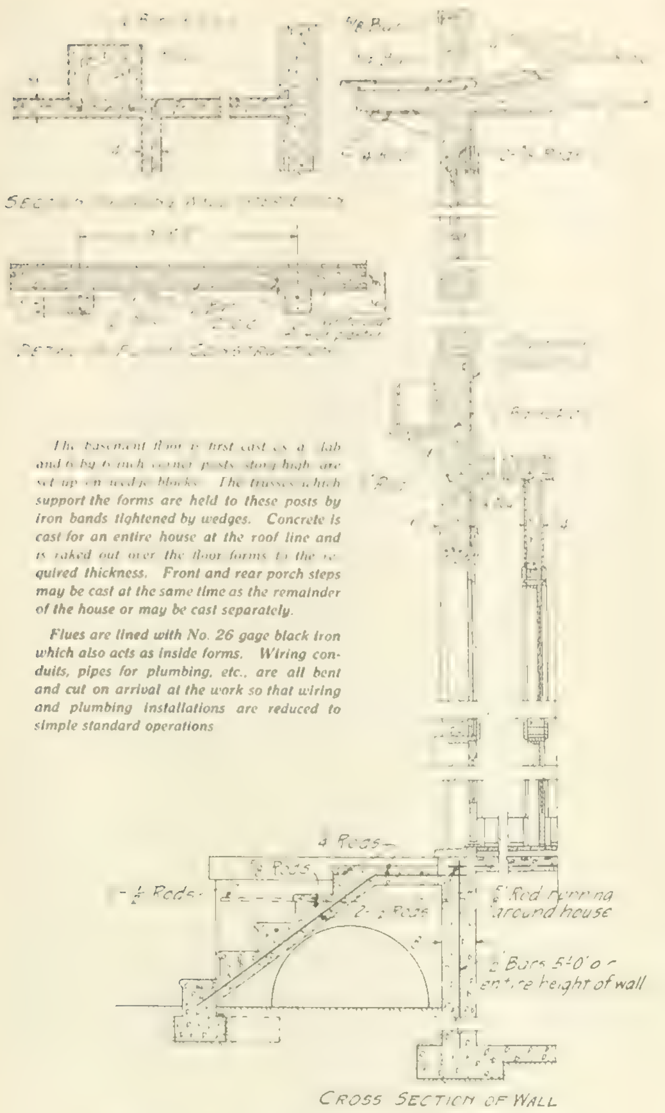
Valley View homes are truly a standardized product. Four and six-room houses have been built, but as the six-room size has proved more popular, additions now being made to the development are six-room houses only. First and second floor plans of these are shown in the illustrations.

The houses have full basements with pipeless heater, have modern plumbing and are lighted by electricity. In the kitchen there are a sink, laundry trays and kitchen cabinets.

Basement walls are 8 in. thick, and the first and second story walls, 6 in. thick, of 1:2:4 concrete. Floors are light beam and slab construction, resulting in a beamed ceiling effect. Floors are covered with wood flooring.

Exterior walls are floated with cement-mortar, then given a thin stucco finish applied with a coarse brush. White, buff and salmon are among the colors used to vary surface tone. Interior of outside walls is plastered on Bishopric board nailed to furring strips embedded in the concrete, so as to provide a 1-in. air space for insulation.

Roofs are reinforced concrete beam and slab construction.



The basement floor is first cast as a slab and 6 by 6 inch corner posts story high are set up on wedge blocks. The trusses which support the forms are held to these posts by iron bands tightened by wedges. Concrete is cast for an entire house at the roof line and is raked out over the floor forms to the required thickness. Front and rear porch steps may be cast at the same time as the remainder of the house or may be cast separately.

Flues are lined with No. 26 gage black iron which also acts as inside forms. Wiring conduits, pipes for plumbing, etc., are all bent and cut on arrival at the work so that wiring and plumbing installations are reduced to simple standard operations

Typical Details of the Ingersoll Concrete House.

Insulation of the roof is obtained by suspending the ceiling on joists, thus providing an air space. The inside of parapet wall, top of cornice and roof surface are coated with waterproof paint.

The only wood in the houses is the floor covering, doors and door frames, window frames and sash, built-in kitchen cabinet and trim.

Table I, compiled from complete, itemized data on the last ten houses built in 1919, shows labor cost and quantities of material required for one of the six-room houses.

Up to the time this article was written, 22 of the four-room houses and 29 of the six-room houses had been completed. Construction of the six-room type has been going on with the expectation that a total of 75 houses would be completed in the development in 1920. A second set of forms for six-room houses is now in use so that two houses per week may be finished.

TABLE I. MATERIAL QUANTITIES AND LABOR COST FOR 6 ROOM HOUSE BUILT IN 1919.

Item.	Quantity of material.	Labor Hours.	Labor Cost.
Excavating	5 cu. yd.	193	$ 83.73
Forms, Erecting		443	195.30
Removing		225	92.53
Moving equipment		27	12.04
Concrete and concreting (entire building)	400 bags cement [illegible] cu. yd. sand 5 cu. yd. gravel		
Cellar floors		66	32.44
Steps		31½	14.86
Building proper		185	81.34
Placing reinforcing	1,951 lb.	22	8.18
Waterproofing	15 gal.	38	17.03
Lathing	1,400 sq. ft. Bishopric board (on wood lath)	29½	16.42
Furring	1,125 lin. ft. 1 by 2 in.	51½	31.94
Plaster and plastering	50 bags scratch coat 27 bags white coat 2 bbl. plaster of Paris		
Plastering		112½	73.36
Patching		9	6.25
Flue lining	112 lin. ft. black iron pipe	11	6.81
Stucco exterior finish	10 bags lime 21 bags stucco	162¾	88.40
Millwork			
Window and door frames		14¼	8.96
Stairs		28½	16.45
Kitchen cabinet		10	6.64
Windows	20 sash	20½	12.72
Doors	11 doors	17	11.14
Carpentry and lumber			
Floors	800 ft. flooring	40	24.39
Inside trim	1,960 lin. ft.	79½	50.27
Framing timbers	228 ft. 2 by 3 in		
Spreaders	440 lin. ft.		
Floor blocks and grounds	1,500 lin. ft.		
Painting, exterior	2 gal. paint	21	10.58
Interior	2 gal. varnish	57	29.13
Plumbing	Kitchen on first floor and bathroom on second floor.	124	71.85
Heating	Pipeless furnace	18	10.40
(Temporary heat)	Account winter construction	5	2.16
		2.037	$1,015.32

Concrete Houses in Valley View Development of Ingersoll-Rand Co.

Research Graduate Assistantships in Engineering Experiment Station, University of Illinois.—To assist in the conduct of engineering research and to extend and strengthen the field of its graduate work in engineering, the University of Illinois maintains 14 research graduate assistantships in the Engineering Experiment Station. Two other such assistantships have been established under the patronage of the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study of engineering, physics, or applied chemistry. An appointment to the position of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of Master of Science will be conferred. Not more than half of the time of a Research Graduate Assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study. Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the Director of the Station each year. There will be 13 vacancies, and in addition two in gas engineering, to be filled at the close of the current academic year. Applications for appointment to these positions should be sent to C. R. Richard, Director, Urbana, Ill., before March 1.

Selling Construction to Labor*

By MEYER BLOOMFIELD,

Editor, Bloomfield's Labor Digest, Boston, Mass.

Every day our newspapers print items which have to do with our country's basic industries; and perhaps the [illegible] amount of space is given to that most important of industries, the construction and building industry.

This is true of the foreign press also. If you scan the English journals, you will find a similar abundance of reference to the building trades. Our housing situation for the past three years has brought out the true importance of this industry, has educated the public to the basic importance of this industry, and has awakened the public mind to the necessity of acting toward it in a way which will help to keep it sound and growing.

But this awakening has not gone far enough. Although the public has now learned something about its dependence on the building industry, and how much its own comfort and convenience in carrying on its affairs hangs together with the prosperity of the operators, it has done little to help in a constructive way. Obviously those connected with the industry must take the needed steps themselves, and while doing so continue the process of public education.

It is clear that conditions being what they are, no industry can be expected to give the public a full measure of the service which it expects, unless there is some team work between the two.

Industry Must Advertise Itself.—In two directions the building industry must take the initiative, and enlist general cooperation:

The common labor supply must be so directed as to result in some sort of preference in favor of the construction trades. One promising source of such supply is in the increasing immigration at our ports this year. If you interview a large number of the alien workmen who land at Ellis Island you will find that a large number of them, if they have heard of anything American at all, have heard of Detroit and its automobile industries. Many of them are headed in that direction. Now there can be no objection to this, of course. Every industry is entitled to its share of available labor. But that share should be a fair one.

It may be that at certain times the building industry cannot use such alien arrivals. But there are other times when their absence in this industry causes a serious handicap, and retards the building operations on which we all depend.

Out of nearly half a million aliens who came to this country during the first six months of 1920, there were only a few thousand men skilled in building occupations. Something like 80,000 laborers were admitted, but more than twice that number returned to Europe within the same period. It is fair to say that the building trades gained little or nothing from the coming of these few thousand, and probably lost a good deal by the large number of departures.

What should be done? Either the public agencies, or some private agency must get to work to call attention to the needs and the opportunities in the building trades. Naturally such work will be suspended in dull times, but it should be active when conditions are good. I am suggesting a campaign of "salesmanship."

Our acute building needs, and the advantages of this industry available to its workers, must be put on the map and known to every "prospect."

Building Industry Must Recruit and Train Workmen.—The second necessary step is in the direction of maintaining the high level of production and workmanship which the industry and the public alike demand. The public welfare depends on it. The only sure way to accomplish this is through systematic training of those who are looking forward to careers in this industry.

From every point of view such a training program is desirable. As regards the individual worker, if he is really concerned for maintenance of his standard of living, based on his productive skill, no greater danger threatens such standard than competition from his fellows of lesser skill and ability.

It is to the interest of every worker, and this is true of every professional man as well, to keep a high standard of performance in force so as to prevent a breakdown of their chief asset—their trade skill.

Clearly, too, no industry can make any headway unless some orderly and constructive process of recruiting its workers and insuring a proper quota of competent ones, is at work. The public pays the bill, as do employer and employe as well, when no such process, a safeguard to all, is part of the industry's program.

A system of apprenticeship is necessary to every occupation which has any standards of service and workmanship to maintain. Without such system, there is no assurance against slipping back with very costly results to all concerned.

Every great industry—and the small as well—owes it to itself and to all those who are employed in it, and to those who look to it for skill and service, to guard most jealously the hard won place it has won as a high grade occupation It must resist cheapening and degrading influences which arise out of poor performance. It best protects its future by preparing young men to come in with the training which alone keeps secure the ground thus far gained. More, too, any hope of further advance rests on an increasing number of trained men attracted to the industry.

There are and have been other ways of developing skill but none so direct, sure and economical as the way of apprenticeship and systematic training, because apprenticeship is a positive method of fixing for good the valuable experiences that develop in a given industry.

Training is insurance for all who care to see their occupation grow in personal opportunity, in public esteem, and in genuine service.

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*From the December Bulletin of the Associated General Contractors.

Skillful Underpinning Prevents Warehouse Collapse

Replacement in successive small units of the rotted pile foundations of a Chicago warehouse averted partial collapse of the building, and, perhaps, obstruction by the ruins of the nearby channel of the Chicago River. How this work was handled is described by Mr. J. J. Rosedale, Construction Engineer of the Industrial Accident Commission of the State of California, in California Safety News, a publication of the Commission. A lowering of the water level since the foundations were constructed is the attributed cause of failure. Almost complete decay of the pile tops and grillage capping was disclosed when, after serious settlement of the building, the foundations were uncovered and unsuspected danger of sudden collapse appeared. The reconstruction restored the original secure condition of the building. It is an 8-story structure with brick walls, iron columns, steel floor beams and wood floors, and was built in 1872. Originally, the front wall was on line with the second row of columns. After a fire in 1881, the building was widened 18 ft. its whole length, the addition being supported on pile-and-grillage column, and wall footings built where the old wharf had been.

Settlement began to be noticed about two years ago, but about the middle of 1919 it assumed serious dimensions. A crack in the west end wall opened from footing to roof. In the front wall the joints opened up in zigzag cracks; the window arches cracked and spalled; the stone lintels broke in two, and the bottom of the wall shoved out about 2½ in. In this condition of progressing failure reconstruction was begun.

So dangerous was the building considered by the contractors that they feared to touch the foundations until the front wall had been anchored as firmly as it could be. On every other floor, at each transverse line of columns, holes were drilled through the walls and steel rods carrying broad outside anchor plates were carried back to bands on the third row of columns and pulled taut. The settlement had been greatest for some 50 ft. about mid-length of the front wall, and therefore reconstruction was begun here. The settlement to be overcome was nothing to 7 in. All six floors of the building were laden with sacks of coffee and chests of tea, the load being estimated to be about 150 lbs. a square foot.

Two steel I-beams about 26 ft. long were set parallel on each side of the wall. Needle beams resting on the I-beams were inserted through the wall and the I-beams were then blocked and wedged up to a firm bearing. A 6-ft. section of the wall footing was then cut out, the grillage removed, the piles cut off to sound wood below water level and the trapezoidal concrete footing was constructed.

When the concrete so placed had set, the space between footing and bottom of wall was filled by three longitudinal rows of screw jacks set so as to touch each other. Then another 6-ft. section was removed and rebuilt, and so on, until the whole of the part affected by settlement had been supported. The column footings were replaced by similar methods, a nest of 24 jacks being put under each column.

When the operations outlined had been repeated until the columns, the front wall and the west end wall (back to the crack) were on jacks, the raising was begun. By simultaneous advances of one-eighth of an inch the jacks were screwed up until the floors and walls were level. During the raising, practically all the cracks were closed. Finally, the jacks were removed a few at a time and replaced with brick masonry. To insure the new front-wall footing from sliding forward it was anchored back.

An Informational Service Concerned with Metals and Alloys. An Alloys Research Association is being formed with an Alloys Informational Service as the first step. This is to be co-operative on the part of those interested in metals and their alloys. An Advisory Committee, composed of 17 prominent technical men, was formed some time ago and this committee has evolved a plan, in conference with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, whereby a service of a different scope from any now existing can be carried on for the benefit of the alloy men. It is now planned to create a special scientific staff composed of a director and a corps of assistants who will give all their time to rendering a service of two distinct types: (1) Current Informational Service—supplying information as to new results; (2) Reference Service—supplying as fully and promptly as practicable all existing information relating to any phase of a subject. The Board of Managers, appointed by three of the divisions of the National Research Council, is constituted of Mr. Alfred D. Flinn, Secretary of the Engineering Foundation, Dr. R. B. Moore of the Bureau of Mines, and Mr. W. M. Corse, Secretary of the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers. The Research Extension Division of the National Research Council, Washington, D. C., which is aiding in the organization, will be glad to supply fuller details about this service.

New $100,000,000 Bridge Proposed at New York City.—A further step toward the construction of a new Hudson River bridge at New York City was taken last week by the filing of incorporation papers by the Hudson River Bridge Corporation. The purposes of the corporation are to further the objects set forth in the charter of the Hudson River Bridge Company, created by act of Congress in 1890, by organizing such corporation or corporations and by taking such other measures as may or will bring about the construction of a great double-deck highway and railroad bridge and all its necessary appurtenances, including a classification and terminal yard in New Jersey, an elevated railroad on the west side of Manhattan for freight and passengers, a union station in Manhattan for the railroads now terminating in New Jersey, and a moving platform under 57th St. and across the bridge. The entire plan is estimated to require seven to eight years and a total investment of about $200,000,000, of which approximately one-half will be represented by the bridge itself. The work will be done with private capital. Gustav Lindenthal, New York City, is chief engineer of the corporation.

Output of Bricklayers.—The Mason Contractors' Association of the United States and Canada at its annual convention at Detroit, Dec. 6, 7 and 8, adopted a resolution that it was the sense of the convention that the "journeyman bricklayers of the United States and Canada, as a whole, except in isolated cases, are now producing an amount of work that compares favorably with that of pre-war years, and that they are co-operating with the mason contractors to the end that the public may be given more production, which makes for lower building costs and more homes."

More Apprentices Needed in Building Trades

Senator William M. Calder, of New York, who, as Chairman of the U. S. Senate Special Committee on Reconstruction and Production, recently completed a nation-wide survey of the housing situation of the country, visiting most of the larger cities as far west as Denver, and receiving answers to questionnaires from every city and village in the United States, believes that one of the most important problems facing the nation today is that of obtaining sufficient skilled workmen in the building trades. The Senator has written letters to the governor of every state in the union, urging that steps be taken to establish trade schools in the several states for the purpose of encouraging young men to learn trades. Senator Calder believes that the building trades offer opportunity for young Americans unequaled in any other line of business in the country. Senator Calder's letter to the governors, which sets forth important considerations in the present building situation follows:

A comprehensive study of the causes of the present shortage in housing and of the various factors entering into the building industry which have tended to retard its progress, has been conducted by this committee during the past eight months, and although we have not been able to visit every state in the Union, we have covered all which the time at our disposal has permitted, and have interrogated authorities from all over the country in order to give a national scope to the study. Our investigation has enabled us, as a result of the perspective thus afforded, to ascertain some of the things which will remedy the conditions which are unsatisfactory and which hamper reconstruction.

One of the outstanding factors which is now hampering the building industry is the curtailment at the source of supply of skilled tradesmen. The building industry is more highly organized than any other large industry, but it is noticeable everywhere that its members are now getting along in years and in some trades the skilled young man is a rarity. It has been the experience of the past that the skilled mechanic in the building trades drops out very much earlier than in any other trades and is forced to take up other or less skillful employment. His pay has accordingly been somewhat higher than the usual run, but the necessity for constant replacement has been ever present.

The American youth takes kindly to the particular trades which require a little more skill than the others, and so we find among the electricians, the plumbers and the masons numerous young men of American birth, but such is not the case with the other trades. Heretofore men from foreign shores, dissatisfied with the political and social conditions existing in their fatherland, have come to this country and, without serving a technical apprenticeship, they have started at the bottom of the ladder in the building trades. Those who have been worthy have risen to heights limited only by their ability. The country was a huge industrial training school where the building trades were taught largely to newcomers to our shores, but the ravages of war cut off this source of supply and the result is apparent on every hand. The remedy seems plain—more apprentices. This goes to the essence, for without apprentices we shall soon be short of journeymen not only, but of foremen and practical employers. The problem is: How shall this be achieved? The best solution seems to be through the fostering of building trades schools. Some of the states have, under their labor codes, authorized a State Industrial Commission to operate an Apprentice Department.

Another thing which has been patent in all of our investigations is that the supply of labor is depleted through over-specialization. There are trades, such as paper hanging, in which work is done but a few months in the year. This particular trade being the busiest, of course, just prior to the two seasonable rental dates, with the result that these particular trades are and must be highly paid, or else the men who participate therein must be competent to function in other trades in the off seasons. This leads to the thought that extensive government aid to trade schools in which apprentices may be trained in a sufficiently wide range of related activities to enable them to adjust themselves to changes in industrial conditions and seasonable demands of the construction industry, would be beneficial not only to the tradesmen themselves but to the body politic.

Summarizing the above, I solicit your good offices in promoting the replacement of the fast dwindling supply of building tradesmen through an adequate system of trade schools which shall be conducted along lines mentioned above, and I request that you at your early convenience give me the benefit of your counsel as to what has been done in your state along this line or what you believe can be done.

Examinations for Engineers' Licenses

The following abstracts of the examination requirements of all states in which engineers are now required to obtain licenses before being allowed to practice, together with the addresses of the officers to whom application must be made, are reprinted from the November Proceedings of the American Society of Civil Engineers:

Colorado.—Each candidate is examined in that branch of engineering in which he is proficient, as set forth in his application. The Board conducts the examination in such a manner as it deems best suited to determine the fitness of candidates, and it may summon any licensed engineer to assist in preparing for and in conducting examinations. Fee for examination is $10, for license certificate $5, and for renewal certificate, $5 annually. Application for examination is made to State Engineer, Secretary, State Board of Engineer Examiners, Denver, Colo.

Florida.—The Board has ruled that examinations may consist of the applicant's sworn statement of professional education and experience in responsible charge of engineering work. If this statement is not complete or qualifying, the Board may summon the applicant to appear for further examination, and investigate his record of professional service. Examinations may be either oral, or partly oral and partly written. Fee for examination is $15, for certificate of registration $10 additional, for registration without examination $25, and for renewal of certificate, 5 annually. Application for examination is made to the Secretary, State Board of Engineering Examiners, 215 E. Bay St., Jacksonville, Fla.

Idaho.—Examinations are held semi-annually in the State Capitol, Boise, Idaho, beginning at 9 a. m., the second Tuesday of March and September. Application must be received 10 days before the date of examination. Fee for residents is $10, for non-residents $25, for renewal, $2 annually. Application for a Certificate of Registration is made to the Department of Law Enforcement, Boise, Idaho, in writing under oath in such form and accompanied by such proof of the applicant's fitness to practice as the Department may from time to time prescribe. Must be accompanied by an unmounted photograph taken within a year.

Illinois.—Structural engineers' examinations include written and oral tests, and embrace subjects normally taught in schools of structural engineering. They occupy three days and cover theoretical and applied mechanics, definitions, general engineering knowledge, stress analysis, static and moving loads, design and construction in reinforced concrete, steel, wood, masonry and foundations. Fee for examination $10, for certificate of registration $5, for examination to determine preliminary education, $5, for restoration of an expired certificate $5, for renewal of certificate $1 annually, for certificate to those who hold a like certificate from another state or county, $15. Application for certificate is made upon prescribed blanks to the Department of Registration and Education, Springfield, Ill.

Iowa.—Examinations are required as prescribed by the Board. Fee for examination $15, for certificate of registration $10 additional, for certificate without examination to person registered in another state, $10. Application for examination is made to the State Board of Engineering Examiners, Box 923, Des Moines, Iowa.

Louisiana.—Examinations are required of all who are not graduates of an engineering college or school of good standing. Examination for surveying covers geometry, plane trigonometry, plane surveying and practical use of instruments; for engineering, covers in addition, physics, including practical problems in design and construction. Fee for examination $25, for registration by diploma $25, for registration of holder of license from another state $15, for issuing license certificate $1, engineering renewal license $3 annually, surveying renewal license $1 annually. Application for license or examination is made to the State Board of Engineering Examiners, Maison Blanche Building Annex, New Orleans, La.

Michigan.—Examinations are required of all who desire to begin the practice of architecture, engineering or surveying as principal or in responsible charge, except those from other states, and include English language and other appropriate subjects. Fee for examination $5, for certificate of registration $15 additional, for certificate of registration without examination $20, for renewal of certificate $5 every five years. Application for examination is made to the State Board of Examiners for the Registration of Arcihtects, Engineers, and Surveyors, 80 Griswold St., Detroit, Mich.

New York.—Present practitioners must obtain licenses before May 14, 1922. If evidence presented in the application does not appear to the Board to be conclusive or warranting issuance of a certificate, applicant may present further evidence, which may include the result of a required examination. Fee for certificate to practice engineering or land surveying $25, for certificate to practice both engineering and land surveying $35. Application for certificate must be made on a prescribed form to Regents of the University of the State of New York, Albany, N. Y.

Oregon.—Examinations may be either oral or partly oral and partly written. Fee for examinations $10, for certificate of registration $5 additional, for certificate of registration without examination $15. Application for examination is made to the Secretary, State Board of Engineering Examiners, Corbett Bldg., Portland, Ore.

Virginia.—Examinations are required of all applicants except those from other states, as prescribed. They are held at least once each year at Richmond, Va., and at such other places and times as the Board may designate. Fee for each examination is $20. Application for examinations is made to the State Board of Examination and Certification of Architects, Professional Engineers, and Land Surveyors, Richmond, Va. Registration is optional; present practitioners are not limited as to time within which to register.

Wyoming.—Examinations are required of all applicants except those licensed under previous acts, and consist of a written examination and an investigation by the Board of record, training, and experience. Fee for examination $10, for certificate of license without examination $5. Application for examination is made to the State Board of Examining Engineers, Cheyenne, Wyo.

Instrument for Automatic Control of Humidity in Shops

Devices for controlling humidity in shops are of three types. The first are makeshifts, such as wet sawdust strewn on the floor, troughs of running water at the sides of the room, or simply an ordinary sprinkling can. Such crude devices are not in any sense self-regulating, and even with the most careful personal attention produce only haphazard results. The sprinkling-can type of humidifier has been in use for hundreds of years and is of interest chiefly because it shows that the need for air-conditioning apparatus in many industrial plants has been recognized for a long time. A second class of humidifiers includes those that are capable of increasing the moisture in the air up to the point for which they are set, but cannot decrease it. When the weather forces the humidity above the desired point, such instruments remain inactive. Few instruments of this type attempt any control of the temperature. A third type of conditioning apparatus is that which is able to hold the atmosphere in a room at a constant temperature and humidity irrespective of outside conditions.

An instrument which absolutely controls both the temperature and the humidity of the air has been developed at the Forest Products Laboratory, Madison, Wis. For several years this apparatus has maintained in the laboratory wood-parts storage rooms the typical climatic conditions found in various parts of the United States, ranging from the hot, moist climate of the South to the cold, dry climate found in the mountain regions. The same type of instrument also keeps the wood-working rooms at the laboratory at uniform temperature and humidity year in and year out, with the result that the wooden articles manufactured there give the minimum amount of trouble afterwards from warping and checking, and the shop conditions are healthful and comfortable to the highest degree. These instruments have required very little personal attention since they were installed.

The principle upon which the laboratory automatic humidity-control apparatus works is that of cooling the air to the dewpoint temperature for the desired atmospheric condition, saturating it with moisture at that point, and then heating it without addition of moisture to the required room temperature. For any given room temperature it is possible to get any humidity desired, simply by choosing the temperature at which the air is saturated.

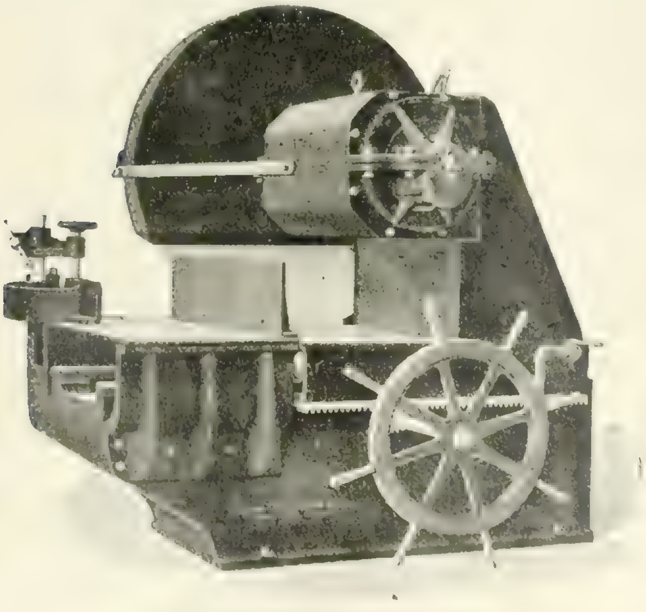
The apparatus consists of a small cabinet, or chamber, through which the air is drawn as often as it needs to be conditioned. The conditioning chamber contains water sprays whose temperature is kept constant by a mixing valve. These sprays suck in the air by their own action, cool it to the temperature at which it should be saturated, and give it all the moisture it can hold. As the air leaves the chamber it is heated to room temperature by coils, whose steam supply is controlled by a thermostat located in the outlet. Thus when the air is drawn into the chamber it may be too hot or too cold, too moist or too dry, but the apparatus automatically humidifies or dehumidifies it and brings it to the correct temperature before allowing it to pass again into the room. Both in the storage rooms, where the air needs conditioning very infrequently, and in the workrooms, where it is completely changed every 10 minutes, the recording instruments show that the atmospheric conditions have varied to only a slight extent throughout a three-year period.

This method of air conditioning was developed primarily for woodworking shops and wood gluing, finishing, and drying rooms. It is adaptable, however, to numerous other industrial plants, including textile mills and chemical, foodstuff, and tobacco factories, in which close control of atmospheric conditions would be beneficial to both the material being manufactured and the health of the employes. It is practicable wherever there is a supply of cold water and steam heat.

Drawings of the apparatus and further details concerning its installation and operation may be had on application to the Forest Products Laboratory.

New High Speed Friction Saw for Cutting Structural Steel

A new high speed friction saw designed especially for the rapid cutting of structural steel has been brought out by Joseph T. Ryerson & Son, Chicago. The machine consists of a very heavy cast iron base of box section, supporting the horizontally travelling carriage to which the motor is bolted. Large rollers on ball bearings are mounted on eccentric shafts to provide adjustment for wear and facilitate traversing of the saw carriage. Bolted directly to the saw blade side of the carriage, is a hood of heavy sheet metal, arranged to be opened for the purpose of examining or removal of the blade. The direct mounting of the disc or blade on the armature shaft of the motor, the special heavy duty motor which was developed after years of systematic experimental work, and the improved feeding mechanism are features of this saw. The blades are of a special grade of soft steel, balanced, hollow ground and nicked on the edge to increase the friction. The blade is held in place by two heavy cast steel, balanced collars, and is cooled by jets of water under pressure directed against the cutting edge. The motor is entirely enclosed on the saw end, and the outer end semi-enclosed by means of cast grids and wire mesh in order to insure ventilation. The shaft is of liberal proportion, made of the best alloy steel and provided with a thrust bearing to eliminate endwise movement or float in the armature or rotor. Movement of the carriage is accomplished by hand or power. The power feed, a special electro-hydraulic feeding device, consists of a cylinder and piston connected to the base of the machine and under side of the carriage respectively, a 1 H.P. motor driving a gear pump, suitable tank, pressure relief and four-way controlling valve. The machines can be furnished for any current or voltage, and are equipped with combination hand wheel and electro-hydraulic feed. The machines are built in four sizes similar in size and differing only in capacity. For the railroads and shops handling the heavy structural work the No. 3 or No. 4 size is recommended. For the shops handling the lighter structural work the No. 1 or No. 2 size is recommended.



Ryerson High Speed Friction Saw

Fixed Fee Basis for Contract for Erecting City Buildings

The city of Cleveland, O., has adopted the "fixed fee basis" for the contract for constructing its new hospital buildings. The procedure is outlined as follows in a letter to contractors asking them to submit propositions:

> The city of Cleveland desires to make an immediate start on the erection of the new city hospital buildings and to complete them in the shortest possible time. As the plans and specifications cannot be sufficiently developed for some weeks, in order to enable the awarding of contracts for these buildings on a lump-sum basis, and for the reason that the labor and materials are on the downward trend, the city of Cleveland is desirous of taking advantage of any saving which might be effected by proceeding with the work immediately.
>
> Therefore, it has been decided to erect these buildings under the provision of the city charter which enables the city to operate and construct buildings under the "Direct Employment of Labor and Purchase of Supplies" Clause. In order to efficiently carry out work of such magnitude on this basis, it is desired to employ a contracting firm to take full charge of the construction, to render aid in the purchase of supplies and materials and in the employment of labor, and in rendering all other such services as are customary and required of a general contractor. Therefore, you are respectfully requested to submit a proposition for executing this work, on what is known as a "fixed fee basis," and this proposition must be delivered in writing to the Director of Public Welfare not later than 12:00 o'clock noon, Thursday, December 23, 1920, and must be in accordance with the conditions herein contained. This operation outlined shall be built under four separate units, namely:
>
> A Main Ward Building, etc.
> A Psychopathic Building, etc.
> Nurses' Home Building, etc.
> Contagious Disease Building, etc.
>
> The requirements by which you are to be guided in submitting this proposition are as follows: The fee should include all your overhead expense in connection with your general office expense, of every kind and description; the providing for the paying of the salary of a high grade general superintendent, satisfactory to the city architect, who shall at all times represent you at the job and receive instructions for you from the city architect or his representatives; the cost and expense of all power equipment of every kind, such as derricks, hoists, motors, concrete mixers, mortar mixers, dump cars, steam shovels, locomotives; the providing for crete buggies, and all other tools required to carry out and complete the job, in such numbers as may be in the opinion of the city architect necessary to carry on the work as rapidly as desired; the maintenance of all equipment and tools in repair, the cost of the cartage of all equipment and tools to and from the site, and the cost of a bond to the city of Cleveland in the amount of one-half of the fixed fee.
>
> All trades and work shall be included in this agreement with the exception of the mechanical trades, which shall be classed as plumbing, heating, ventilating, electric work and elevators.
>
> The city of Cleveland will purchase all materials through its purchasing department upon the requisition for quantities of such material as shall be estimated by the contractor, after said requisition has been delivered to the city architect for his check and approval. The city shall also pay all men employed on the work (with the exception of the general superintendent as hereinabove mentioned) each week upon the filing of the pay roll with the city

architect which shall be later filed with the city treasurer. The city shall also pay for insurance covering indemnity, liability and workmen's compensation.

All material such as fuel for plant operations, also scaffolding and all materials other than above mentioned will be supplied by the city.

Each firm submitting a proposal as above outlined should include a statement relative to the service which the firm would be capable of rendering.

Plot plan drawings showing the exact location of these units will be furnished to the bidder on request at the City Architect's office. A thorough explanation of the procedure will be given.

Building Operations in 1920 and Forecast for 1921

The amount of money involved in construction contracts during 1920 in the 25 northeastern states of the country was practically the same as in 1919, according to statistics compiled by the F. W. Dodge Co. On account of greatly increased construction costs, this amount of money, something over two and a half billion dollars, paid for a volume of construction that was nearly one-fourth less in 1920 than in 1919.

The year 1920 opened with a rate of construction activity unprecedented for the winter season. Total contracts reached a maximum of over three hundred million dollars in the month of April. From that time on, for causes well known generally, activity declined more or less steadily to the end of the year. December contracts amounted to one hundred million dollars.

Comparing the past two years, the most conspicuous feature of 1920 was the decline in residential construction. This class of construction represented 33 per cent of the total in the year, 1919, and 22 per cent of the total in 1920. The amount of residential floor space contracted for declined from 240,000,000 sq. ft. in 1919 to 136,000,000 sq. ft. in 1920.

In the amounts of money involved in 1920 contracts, industrial plants and public works and utilities both exceeded residential buildings, each representing about 23 per cent of the year's total.

There was in 1920 an increase over 1919 in actual volume of construction of educational buildings.

In normal years the total estimated cost of contemplated or projected work reported is about 50 per cent in excess of the total amount of contracts awarded. In 1919 the total of projected work was 68 per cent in excess of contracts awarded; in 1920, it was 92 per cent in excess of contracts awarded. These figures give an indication of the amount by which each of the two years has run behind its announced construction program.

The outlook for 1921 is set forth as follows in the F. W. Dodge Co.'s review of building activity, made public on Jan. 9:

The construction industry enters the new year under conditions very similar to those that prevailed at the opening of the year 1919.

There is a considerable accumulated demand for building, and activity is very slow on account of unstabilized price conditions and hesitation on the part of prospective builders because of uncertainties of future market conditions.

At the opening of 1919 building material prices had remained, on the average, at about the same level for four months. They continued at this level during the first quarter of 1919. About April, 1919, many people were convinced that building costs would not fall, and activity increased rapidly. About two-thirds of the total of that year's activity was contracted for during the second half of the year.

It seems likely that a somewhat parallel movement may be expected in 1921. Material prices have not as yet reached the stage of stabilization they had reached at the opening of the year 1919. Apparently some further declines are to be expected. It seems likely, however, that the period of stabilization and of hesitation on the part of the buying public need not be so prolonged as it was two years ago. When costs are actually stabilized it should be more easy this time to convince the public that such is the case.

In an analysis of the present price situation, a well-known authority has stated that the upward turn in material prices will probably occur some time in 1921 and that, in consequence, building costs in 1921 will be somewhat lower than they have been in 1920 or will be in 1922 and 1923.

If that be true, then price conditions will be more favorable to building activity in 1921 than they were in 1920 or will be next year. If the public comes to believe that is the case, then a resumption of activity should be expected in 1921.

Not a few leaders in the construction industry expect a revival of construction activity in the spring, to be followed by increased activity through the summer and fall.

Awakened interest in construction activity is shown by the fact that the amount of contemplated work reported in December aggregated more than for any month since June.

A volume of construction equal to that of 1919 on a cost basis somewhere near the 1919 level may be given as the most reasonable forecast for 1921. In money this would involve about two and half billion dollars for the 25 northeastern states of the country, the same as the figure for 1920, though on a cost level that should represent a volume approximately one-third greater than the 1920 volume of construction.

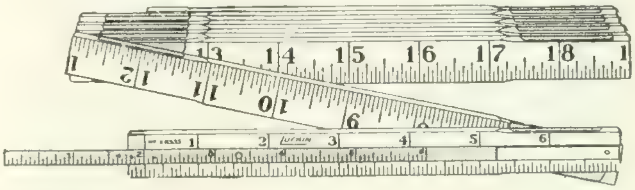
Should conditions develop so favorably that the full demand for construction may assert itself, the end of the year might possibly show a total of as much as three billions for the 25 northeastern states.

Developments of the next three months should indicate whether the year's total of construction activity is likely to be nearer to two and a half to three billions of dollars.

In 1921, residential construction and the construction of public works and utilities may be expected to predominate over other classes of buildings.

New Extension Spring Joint Boxwood Rule

A new 6 ft. extension spring joint rule, particularly designed for taking inside measurements of openings, such as door and window frames and similar fixed points, but just as handy as a common rule for ordinary measuring, has just been put on the market by The Lufkin Rule Co., Saginaw, Mich. While somewhat similar in pattern to a spring joint rule, it is made of genuine boxwood in natural finish. The first section of the rule is fitted with a graduated brass slide, which extends readily but is not loose and cannot fall out, having end lock. To take an inside measurement, open the rule to within 6 in., or less, of the distance between the points. Extend the brass slide by push button. Add the measurement on the brass slide to that shown at extreme end of rule, which gives the exact distance. The extension slide is also admirably adapted to determining depth of mortises, etc. The boxwood sections are somewhat heavier than those of a common spring joint and are securely fastened at joints, making the rule more rigid when extended than the ordinary folding rule. The graduation is consecutive inches and 16ths, both sides, with distinct lines and figures.



New Extension Spring Joint Boxwood Rule.

Failure to Comply with Nebraska Labor Law Costs Steel Erector $8,715.—The state labor law of Nebraska requires that contractors erecting steel frame buildings must thoroughly plank every tier of iron or steel beams as the building is constructed. Failure to comply with this regulation recently cost a contractor $8,715. Last June a workman employed on a new building as a structural iron worker, fell from a steel beam high in the air to the ground and was killed. Under the Workmen's Compensation Law ordinarily his widow would have received but $4,474. However, it was revealed that the builders had neglected to plank the floors of each story as the building progressed. This was in violation of the Nebraska labor law. Suit was led against those responsible. The case was settled outside of court and the widow was awarded an additional $8,715.

First 100 Cities of United States

The first 100 cities of the United States in order of population, according to the figures of the U. S. Bureau of Census, are as follows:

City	Population, 1920.	Increase, 1910-20. Per cent.
New York, N. Y.	[illegible]	17.9
Manhattan Borough	2,284,103	—2.0
Bronx Borough	732,016	69.8
Brooklyn Borough	[illegible]	23.7
Queens Borough	466,811	64.3
Richmond Borough	115,959	34.9
Chicago, Ill.	2,701,705	23.6
Philadelphia, Pa.	1,823,158	17.7
Detroit, Mich.	993,739	113.4
Cleveland, Ohio	796,836	42.1
St. Louis, Mo.	772,897	12.5
Boston, Mass.	748,060	11.6
Baltimore, Md.	733,826	31.4
Pittsburgh, Pa.	588,193	10.2
Los Angeles, Calif.	576,673	80.7
San Francisco, Calif.	508,410	21.9
Buffalo, N. Y.	506,775	19.6
Milwaukee, Wis.	457,147	22.3
Wasnington, D. C.	437,571	32.2
Newark, N. J.	414,216	19.2
Cincinnati, Ohio	401,247	10.4
New Orleans, La.	387,219	14.2
Minneapolis, Minn.	380,582	26.3
Kansas City, Mo.	324,410	30.6
Seattle, Wash.	315,652	33.1
Indianapolis, Ind.	314,194	34.5
Jersey City, N. J.	297,864	11.2
Rochester, N. Y.	295,750	35.6
Portland, Ore.	258,288	24.6
Denver, Colo.	256,369	20.1
Toledo, Ohio	243,109	44.3
Providence, R. I.	237,595	5.9
Columbus, Ohio	237,031	30.6
Louisville, Ky.	234,891	4.9
St. Paul, Minn.	234,595	9.2
Oakland, Calif.	216,361	44.1
Akron, Ohio	208,435	201.8
Atlanta, Ga.	200,616	29.6
Omaha, Nebr.	191,601	54.4
Worcester, Mass.	179,754	23.1
Birmingham, Ala.	178,270	34.4
Syracuse, N. Y.	171,717	25.1
Richmond, Va.	171,667	34.5
New Haven, Conn.	162,519	21.6
Memphis, Tenn.	162,351	23.8
San Antonio, Tex.	161,379	67.0
Dallas, Tex.	158,976	72.6
Dayton, Ohio	152,559	30.9
Bridgeport, Conn.	143,538	40.6
Houston, Tex.	138,076	75.2
Hartford, Conn.	138,036	39.6
Scranton, Pa.	137,783	6.1
Grand Rapids, Mich.	137,634	22.3
Paterson, N. J.	135,866	8.2
Youngstown, Ohio	132,358	67.4
Springfield, Mass.	129,563	45.7
Des Moines, Iowa	126,468	46.4
New Bedford, Mass.	121,217	25.4
Fall River, Mass.	120,487	1.0
Trenton, N. J.	119,289	23.2
Nashville, Tenn.	118,342	7.2
Salt Lake City, Utah	118,110	27.3
Camden, N. J.	116,309	23.0
Norfolk, Va.	115,777	71.6
Albany, N. Y.	113,344	13.1
Lowell, Mass.	112,759	6.1
Wilmington, Del.	110,168	26.0
Cambridge, Mass.	109,694	4.6
Reading, Pa.	107,784	12.2
Fort Worth, Tex.	106,482	45.2
Spokane, Wash.	104,437	...
Kansas City, Kans.	101,177	22.9
Yonkers, N. Y.	100,226	25.6
Lynn, Mass.	99,148	11.0
Duluth, Minn.	98,917	26.1
Tacoma, Wash.	96,965	15.8
Elizabeth, N. J.	95,682	30.3
Lawrence, Mass.	94,270	9.8
Utica, N. Y.	94,156	26.5
Erie, Pa.	93,372	40.4
Somerville, Mass.	93,091	20.5
Flint, Mich.	91,599	137.6
Jacksonville, Fla.	91,558	[illegible]
Waterbury, Conn.	91,410	25.0
Oklahoma City, Okla.	91,258	42.1
Schenectady, N. Y.	88,723	21.8
Canton, Ohio	87,091	73.4
Fort Wayne, Ind.	86,549	35.4
Evansville, Ind.	85,264	22.4
Savannah, Ga.	83,252	28.0
Manchester, N. H.	78,384	11.9
St. Joseph, Mo.	77,939	0.7
Knoxville, Tenn.	77,818	114.1
[illegible]	77,543	97.4
Bayonne, N. J.	76,754	38.2
[illegible]	76,121	13.7
Harrisburg, Pa.	75,917	18.3
[illegible]	74,683	88.7
[illegible]	73,833	10.0
[illegible]	73,502	41.6
[illegible]	[illegible]	37.5
[illegible]	72,075	296.4
[illegible]	72,013	†6.2
[illegible]	72,013	6.2
[illegible]	70,983	32.2

[illegible]

Definitions and Specifications for Lime.—A circular (No. 106) of the U. S. Bureau of Standards dealing with the above subject is now ready for distribution by the Superintendent of Documents, Washington, D. C., at 5 ct. per copy. The circular describes the quantity of lime required for making plaster and mortar as well as the amount for use as fertilizer. A formula for making whitewash is likewise included.

One Big Sign for All Sub-Contractors on Building Job.—Instead of plastering a building job with a lot of signs advertising various sub-contractors, the general contractors in a number of cities are displaying one big sign containing the names of all the sub-contractors on the project. This new departure not only makes for neatness, but it gives all the concerns connected with the job an equal amount of publicity.

Personals

L. B. Blodgett has resigned as assistant county engineer of Gogebic County, Michigan, to accept a similar position with Houghton County, Michigan.

Edward C. Meyfarth, assistant city manager of Jackson, Mich., has been appointed city manager to succeed A. W. D. Hall, who resigned to become manager of Tampa, Fla.

The Rounds-Clist Co., general contractors, Seattle, Wash., have opened a branch office at 333 Pittock Block, Portland, Ore. L. W. Hansen, construction foreman of the Seattle office, will be the Portland manager.

A. S. B. Little, first assistant engineer of the Public Utilities Commission of Illinois, has resigned. He is said to have accepted a five-year contract with New York City to handle rate matters of the city before the Supreme and Federal courts. Mr. Little has been in the service of the Illinois Commission since 1914, acting in gas litigation.

James Horton, James T. Weir, Clarence Waterfield, G. H. Molan and John Wheelright have organized the Ogden Construction Co., Ogden, Utah, and will engage in a general contracting business.

Albert C. Coutu, A. P. Coutu and Laurence E. Coutu have organized the C. J. Coutu Sons Co., of Arctic, R. I., and will engage in general construction work.

Obituaries

Michael J. Reisner, a building contractor of Portland, Ore., died Jan. 3 at his home in that city.

Matthew Carr, builder of the original system of docks and piers for the port of Sheboygan, Wis., died Jan. 19 at his home in Sheboygan, aged 91.

Maj. A. T. Tomlinson, construction engineer, died Jan. 20 at his home in Toronto, Ont. He occupied many important engineering positions on the Denver & Rio Grande Ry., Brooklyn Elevated Ry., New York Underground Ry., Chicago Elevated Rys. and Boston Elevated. He was also civil engineer for White & Co., New York, coming to Montreal in 1905 as their Canadian engineer. He had charge of the construction of the hydro-electrical development of the surplus water of the Soulanges Canal at Cedars, Quebec. He also directed the construction of a trunk sewer for Edmonton and part of the G. T. P. From 1912 to 1914 Maj. Tomlinson was chief engineer in charge of the surveys and location of the proposed railway from Montreal to James Bay. For the past five years he has been major of the Canadian Engineers in charge of inspection of small arms ammunition in Dominion arsenals.

Industrial Notes

Wallace & Tiernan Co., Inc., on Jan. 15 opened its new plant at Newark, N. J., where henceforth all activities of the business will be conducted, including all the work of engineering, design, manufacture, assembly, testing and shipping, and all laboratory work, as well as sales and executive supervision.

The National Cast Iron Pipe Co. announces that immediately after Feb. 1 its new warehouse plant at Thirty-seventh street and South Ashland avenue, Chicago, will be in operation. A complete stock of 3-in. to 24-in. cast iron pipe and specials, as well as valve and roadway boxes, will be carried at the warehouse.

The John F. Byers Machine Co., Ravenna, O., has announced the following changes and additions to its list of representatives: Mussesns, Ltd., are now exclusive sales representatives in Canada, with offices at Montreal, Toronto, Winnipeg and Vancouver. Edward R. Bacon Co. of San Francisco are now exclusive Byers' distributors for northern California and the northwest, which includes Washington, Oregon and Nevada. Don A. Rathburn Co., El Paso, are exclusive representatives for the Panhandle section, New Mexico, and northern Mexico. F. A. Devlin, formerly president of the Empire Engineering & Equipment Co. of Pittsburgh, who represented Byers in the Pittsburgh district for the last five years, has severed his connection with that company to represent Byers exclusively in that section.

Howard H. Marsh, for nearly eight years district manager of the Railway Age and other publications of the Simmons-Boardman Publishing Co. at Cleveland, O., has resigned to become president of the Victory Equipment Co., with office at 444 Maison Blanche Annex, New Orleans, La. As head of the Victory Equipment Co. he will handle the following accounts: McMyler Interstate Co., Cleveland locomotive cranes, pile drivers and material handling equipment; Ball Engine Co., Erie, Pa., steam shovels and railroad ditchers; Schaefer Equipment Co., Pittsburgh, Pa., truck lever connections, brake levers, brake rod jaws and stake pockets; and Equipment Manufacturing Co., Cleveland, trucks and trailers. His education, business experience and wide acquaintance fit Mr. Marsh for his new undertaking. He is still a young man, having graduated at the University of Vermont in 1903, with the degree of B. S. in civil engineering. That same year he entered the employ of Engineering News (now Engineering News-Record) as assistant to the western manager, and stayed there until 1907, when he was appointed western representative of Engineering and Contracting, with headquarters in Chicago. He left the latter place to go to Cleveland as district manager of the Simmons-Boardman Publishing Co. Mr. Marsh's removal to New Orleans is due to his desire to be near his family, as it was necessary for Mrs. Marsh to take up her residence in the southwest in order that her health might be restored. In addition to his other work, Mr. Marsh will represent the Simmons-Boardman Publishing Co. in the southwestern territory.

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Index of E. & C. Now Ready

The index for Vol. LIV covering the July-December issues of Engineering and Contracting is now ready for distribution. Subscribers desiring a copy should notify us at once. Those who received the indexes for the previous volumes have been listed and need not notify us again.

A Big Road Year and What Engineers Can Do to Make it Bigger

There is excellent prospect that 1921 will be the greatest road construction year in our history. Not only are new appropriations for highways unusually large, but unexpended old appropriations are abnormally great. A very large part of the work that was to have been done in 1920 was held up because of inability to get freight cars. Moreover, labor was scarce and inefficient. Now, however, the railways are able to supply all the cars needed, and laborers are back to their pre-war efficiency.

If any state or county is hesitating about adopting a liberal program of highway improvement, we suggest that the local civil engineering society or club appoint a committee to persuade the public that it is unwise to defer road work. Up to the present, engineers have rarely made organized effort to secure public improvements. They have confined their effort to designing and supervising public works after some one else had secured the appropriations for it. But the time has come when engineers should be leaders of public opinion in all matters relating to public works, and that means that they should become promoters of worthy projects for public improvements. To this end they should address chambers of commerce, city councils, county commissioners and state legislators whenever questions arise as to the advisability of undertaking any important public improvement. They should also write articles for local papers, and arrange to be interviewed by newspaper reporters. Few engineers seem to realize that newspaper editors are always anxious to secure expressions of opinion about public matters from men competent to pass judgment and that they gladly welcome a telephone message asking that a reporter be sent to secure an important interview. Letters to the editor are effective, but not half so apt to attract attention as an interview. A person who is interviewed is regarded as a person of importance, whereas the writer of a letter may be quite unknown and merely interestingly garrulous.

The fine art of getting interviewed is known to most lawyers and business men, but is quite unknown to the average engineer. Yet it is an art easily mastered and well worth mastering.

The Attention Value of the Spoken Word

Between the written and spoken word there is this cardinal difference—the written word can be pigeonholed, the spoken word can not. Whatley, in his Elements of Rhetoric, says:

> It is notoriously difficult to withdraw our attention, even from a trifling talker of whom we are weary, and to occupy the mind with reflections of its own.

This psychological principle is not sufficiently applied by engineers. It is our custom almost to ignore it. Is a legislature in session, and are we opposed to some proposed bill? Then we are apt to send our written objections, if we protest at all, rather than go in person. But such written protests are usually uneffective, partly because they are never comprehended and partly because they lack attention compelling quality. Similarly we are given to reading engineering papers before our societies, rather than uttering our opinions and facts extemporaneously, although we are quite well aware that reading out loud is but slightly more apt to hold the hearer's attention than his own reading in silence holds it.

Ages of listening to the voice of his fellow-men has developed in man a sympathy with vocal utterance that is incomparably stronger than that aroused where the eye follows merely the symbols of the voice. To quote Whatley again:

> The personal sympathy felt towards one who appears to be delivering his own sentiments is such that it usually rivets the

attention, even involuntarily, though to a discourse which appears hardly worthy of it. It is not easy for an auditor to fall asleep while he is hearing even perhaps feeble reasoning clothed in indifferent language, delivered extemporaneously and in unaffected style; whereas it is common for men to find difficulty in keeping themselves awake while listening even to a good dissertation of the same length on a subject, not uninteresting to them, when read, though with propriety and not in a languid manner.

Whatley was writing with especial reference to ministers, but his admonitions are applicable to all men who aim to convey ideas to other men.

Our Department of Agriculture annually prints and circulates hundreds of tons of literature that should be read by farmers. But the slowness with which farm efficiency improves is eloquent evidence as to the inattentiveness of the average farmer to what he sees in print. Obviously the Department of Agriculture must eventually send out hundreds of lecturers to teach our farmers by word of mouth. We hazard the guess that one winter spent in such vocal teaching of all our farmers would do more to improve agriculture than six years of printed educational propaganda.

During the 30-year period of 1889 to 1919 our crop output per farmer increased only 20 per cent, in spite of the truly remarkable quantity of excellent agricultural literature published by the farm papers and the Department of Agriculture. This 20 per cent agricultural increase was deduced in our issue of April 7, 1920. In the same issue it was shown that during the same period our miners increased their per capita annual output 70 per cent! This difference is ascribed largely to the fact that our mines are managed by mining engineers who not only read mining literature but attend conventions to discuss mining economics.

It requires a highly trained mind to read understandingly and persistently a great deal of literature of an educational character. Even trained engineers are usually somewhat deficient in abilty to read attentively all that they should read. How much greater is the defect of farmers and other untrained men in this respect is obvious.

Many applications can be made of the principle that the spoken word is superior to the written word in arousing interest and holding attention, but we suggest at this time only one application. Engineers should address public bodies whenever there is a discussion of matters upon which an engineer is competent to express an opinion.

Is the Quantitative Theory of Money and Prices Discredited by Recent Events?

"The quantity theory of money" in relation to prices is receiving caustic criticism from some editorial writers. For example, the editor of The Saturday Evening Post declares that this theory is discredited by the recent rapid decline in commodity prices in the face of a rise in the quantity of money. We quote:

> This hypothesis was one basis for the statement, so commonly made last summer, that prices could not recede rapidly because the volume of circulating mediums could not be quickly contracted.
>
> That increase in production of goods and trade leads to increase in circulating mediums and credit was amply demonstrated during the past five years. That recession in production of goods and trade would lead to contraction of currency and credits was also postulated, especially as related to banking credits. But that prices could fall heavily while inflation of currency was being increased was not contained in the quantity theory of money. Yet that is exactly what is happening all over the world. In November and December prices were descending precipitously almost everywhere; inventories of goods shrank overnight; stocks and bonds contracted while one looked at them.
>
> At the same time the volume of note circulation and of banking credit was inflated almost to the bursting point. Other factors continue to operate to maintain the volume of note circulation; the fall in prices does not influence it.

It is true that our per capita money has increased slightly, (6 per cent) during the past year, and that wholesale commodity prices have fallen considerably during the same time (25 per cent). This, however, does not discredit the quantity theory of money and prices, for this theory involves more factors than money. The editor of the "Post" overlooks the very important factor of velocity of circulation. A study of that factor shows that its decrease entirely accounts for the drop in wholesale commodity prices. Total money in circulation (M) multiplied by the number of times it is turned over in a unit of time (V) gives the total realized demand (D) for goods and services or $M \times V = D$. During the past year the total demand (D) has decreased, although money (M) has increased slightly; but during the same time the rate of money turnover (V) has decreased slightly more than prices have decreased. The result is that commodity prices have fallen correspondingly.

A complete quantitative theory of commodity prices was published in our issue of April 7, 1920; and it was there shown that the following formulas gives wholesale index prices of commodities with great accuracy:

$$W = \frac{M \times V}{2 \times P \times E}$$

M = total money in circulation.
V = velocity of circulation.
P = total population.
E = per capita productivity.
W = wholesale index price of commodities.

This formula agrees closely with the actual wholesale index prices of the Bureau of Labor for every year for a third of a century, including the calendar year 1920. The formula may be designated as a quantitative theory of money and prices, but it clearly makes evident the fact that there are three factors other than money which must all be considered in any correct analysis of changes in commodity price levels.

Let Contracts Early

The past year from a highway construction standpoint was a sad disappointment. It started with every indication of being "the biggest road building year," but the scarcity and inefficiency or labor and above all the difficulties of getting materials due to railroad congestion early hampered construction operations and later resulted in almost complete stopping of contract letting. But conditions are different now. For the first time in 5 years the railways have a surplus of cars and locomotives. This condition cannot last. The farmers will not hold their crops indefinitely. Industry is not down and out. It will not be long before the transportation facilities of the railroads will be in greater demand for moving wheat and corn and factory products.

Public officials should take advantage of the present situation by an early letting of contracts. By so doing the successful bidders will be able to place their orders at a time when manufacturers can ship promptly and the railways can deliver quickly. Some highway commissions realize this. The Iowa Highway Commission, for instance, says in its October-November Service Bulletin:

> The Highway Commission urges upon contractors the purchase and storage of sufficient building materials during the winter months to if possible complete their work under contract. To further the storage of materials in large quantities it will allow estimates up to 90 per cent of all materials properly stored.
>
> Preparation for lettings on a number of projects is being rushed in order that successful contractors may have an opportunity to get into the market and make winter purchases of materials and in order that they may profit by any transportation advantages that can be secured during the winter months. * * *
>
> The Commission does not anticipate much further if any reduction in the price of building materials. The advantage to be gained by securing materials and having them at hand promptly when the season opens would seem to offset any possible advantage in price that can reasonably be anticipated.

Road School for Kansas County Engineers.—The Kansas State Agricultural College, Manhattan, Kan., will hold a road school for county engineers from Feb. 8 to 18. The course will include 9 lectures on general economics and 9 lectures on engineering economics. There also will be the following courses, which will each occupy 3 hours per day for 9 days; only two of these can be chosen by a student: 1. Surveying, 2. Concrete: Materials and Manipulation. 3. Retaining Walls and Foundations. 4. Design and Erection of Steel Highway Bridges. 5. Design and Construction of Reinforced Highway Bridges. 6. Testing of Non-Bituminous Highway Materials. 7. Bituminous Materials and Their Tests. 8. Construction and Maintenance of Roads and Pavements. 9. Preparation of Federal Aid Plans. 10. Economics of Highway Location and Construction as Applied to the County System. L. E. Conrad, Professor of Civil Engineering, is in charge of the Road School.

Formulas for Determining Width of Roadway

To the Editor: In your issue of Sept. 1, 1920 (p. 201), appears an article by Mr. R. C. Barnett, entitled "The Development of an Economic Theory of Highway Transportation." In this article on page 202 he quotes two formulas which he credits to me. Evidently these formulas were taken from an article which I wrote especially for your paper and which appeared in the issue of April 2, 1919 (p. 328). I find on careful examination that the formulas in Mr. Barnett's article are not the same; either they have been changed to suit his needs or were erroneously deduced.

In determining width of roadway required for one line of traffic, where b′ equals overall width of vehicle in feet and S equals maximum speed in miles per hour, Mr. Barnett gives the formula:

$$\text{Width required for one line of traffic} = b' + \frac{S}{10}.$$

An inspection of Table I in the article of April 2, 1919 (p. 328), indicates the formula to be: Width for one line of traffic $= b' + 1 + S/10$. Mr. Barnett's version would provide no clearance for standing traffic. In recent work I have changed this formula (for minimum value) to equal $b' + \frac{1}{2} + \frac{S}{10}$ The other formula for "allowable density" is given by Mr. Barnett as $Dt = \frac{5280\ S}{2S_m^2 + V}$ in which Dt equals "traffic density" or number of vehicles passing per hour. S_m equals maximum speed in miles per hour. V equals length of vehicle in feet. The original formula as given by me was:

Maximum number of vehicles per hour per line of traffic

$$= \frac{5280 \times \text{Average miles per hour}}{\text{Headway}} =$$

SA equals Average speed in miles per hour of a given line of vehicle. S_m equals Maximum (permissible) speed allowed in miles per hour. F equals factor of safety (see article), usually 2. Mr. Barnett's version gives exceedingly low values.

While these formulas are simple they should be stated accurately.

H. J. FIXMER,
Paving Engineer, Board of Local Improvements.
Chicago.

American Engineering Council to Meet at Syracuse.—The Executive Board of the American Engineering Council of the Federated American Engineering Societies will meet Feb 14 at Syracuse, N. Y. Herbert Hoover will be the principal speaker, and it is expected he will outline the new council's plans for dealing with industrial relations and particularly with human waste as it affects the present army of unemployed. Mr. Hoover will sound the keynote of the American engineer in urging co-operation with Congress, with labor organizations, chambers of commerce and other bodies in the campaign planned by the council to remedy economic ills. The Syracuse meeting will mark the beginning of a movement to organize the engineers on a territorial basis. As a result of a report submitted to the council by Mr. Hoover, the council will probably encourage the formation of state engineering councils, a process already under way in many states, including Massachusetts and Minnesota. Many engineers are in favor of councils of engineers in every state as territorial of the Federated American Engineering Societies. A federation of New York State engineers, it is said, is a probabilty of the near future.

Evolution of Illinois Pavements.—"Traffic demands wider and thicker pavements," declares S. E. Bradt, of the Illinois Highway Commission, in a recent article on the evolution of the Illinois Highway Specifications. In 1913 Illinois plans called for concrete pavement slabs 6 in. thick laid on crowned subgrade. In 1915 the subgrade was made flat increasing the thickness of the center of the slab to 7 in. In 1919 this thickness was increased to 8 in. in the center and 7 in. at the edges. Present plans call for slabs 8 in. thick both center and sides. Widths called for have advanced from 10 ft. in 1913, to 16 and 18 ft.—Service Bulletin of Iowa Highway Commission.

Density Tests of Concrete Made Under Actual Road Building Conditions

Density tests of concrete made under actual road building conditions in Iowa gave results that compared very favorably in the important factor of density to test blocks of concrete produced under laboratory conditions. Out of 27 tests, upon eight different paving projects none showed a lower density than that in tests of similar quality concrete previously made under laboratory conditions which showed a range in density from 70 to 80 per cent. The results of the tests are summarized in the following table:

Mixture.	Tamping method.	Material.	No. of specimens.	Average density.
1-2-3½	Machine	Screened	2	.792
1-2-3½	Machine	Screened	4	.824
1-2-3½	Machine	Screened	4	.809
1-2-3½	Machine	Screened	4	.826
1-2*-1	Machine	Screened	4	.722
1-2.4-2.4	Hand	Screened	2	.770
1-2.4-2.4	Hand	Unscreened	3	.755
1-3½	Machine	Unscreened	4	.754

The methods of making the tests and the purpose for which they were made are outlined as follows in a Service Bulletin of the Iowa Highway Commission:

In brief the objects of the tests were:

To acquire data upon which to base estimates of quantities of materials in the concrete.

To compare compactness of concrete tamped in various ways.

To compare compactness of concrete of various proportions of cement, sand and rock.

In carrying out the tests, molds having a tight bottom and of accurate inside dimensions so that their volume was accurately known, were set upon the subgrade and the concrete operations allowed to pass over them. After the pavement was finished and before the material had time to set, the molds were pulled out and specimens of concrete in the exact degree of compactness of the rest of the pavement thus secured. While still green, the cement was separated from the coarse aggregates, and both dried and weighed. The specific gravity of the materials being known it was then possible to compute the total amount of space occupied by the material. The ratio of this solid volume of material to the total volume of the mold is a measure of the compactness of the concrete. When expressed as a percentage of the total volume it is called the density of the concrete.

Conclusions to be drawn from the 27 tests made by the Materials and Testing Department, are that present day methods of concrete road building are giving concrete of a density that compares favorably with that of concrete made under laboratory conditions.

That under favorable construction methods the data indicates that with 1:2:3½ proportions, machine finished concrete will be 80 per cent dense.

That good uniform pit run gravel containing 70 per cent sand and mixed in the proportion of 1:3½ and machine tamped will yield concrete 75 per cent dense.

These tests indicate a method of computing quantities of materials for mixtures containing varying percentages of sand. If the cement is varied to keep the concrete at equivalent strength the density will decrease as the sand content of the aggregate increases.

The results of the tests so far have been very reassuring as far as construction practices and inspection methods are concerned. The tests were made on the various jobs at times when the construction force knew nothing of them in advance and they represent actual construction practice. The tests will be continued next year upon a large number of projects and under more varied conditions.

Oregon Roads Not to Be Surfaced Until Base Has Stood Season's Traffic.—The Oregon State Highway Commission, according to the Service Bulletin of the Iowa State Highway Commission, has announced that hereafter it will be a settled policy that no surfacing will be done on any road until the base has withstood traffic for one or more seasons and been thoroughly beaten down by actual traffic. It is announced that approximately 100 miles of road will meet these conditions for paving during the 1921 season.

State Highway Construction in 1920 and 1921

Alabama.

The total expenditure in 1920 under the direction of the State Highway Department for roads completed in that year was $1,568,465. In addition $55,000 was expended for concrete bridge work. The mileage completed during 1920, and its cost were as follows:

Type of roads	Miles.	Total cost.	Av. cost per mile.
Asphalt pavement on concrete base	[illegible]	[illegible]	$42,943
Gravel and chert	29.03	[illegible]	6,552
Sand-clay	[illegible]	[illegible]	5,695
Road graded	3.19	[illegible]	14,679

The mileage under construction on Jan. 1, 1921 (contracts carried over from 1920) was:

	Miles.
Asphalt pavement on concrete base	1.71
Gravel road	79.49
Sand-clay	67.59

The estimated expenditure for 1921 is $5,693,729, of which the state's share is $2,796,864. The total includes a concrete and steel bridge estimated to cost $142,932. The types of construction and estimated costs are as follows:

Type of roads	Miles	Estimated cost.
Bituminous macadam	65.12	$1,820,995
Gravel road	183.85	3,016,045
Sand-clay	[illegible]	539,195
Asphalt pavement	4.11	124.558

W. S. Keller, Montgomery, Ala., is State Highway Engineer.

Arkansas.

The following statistics were compiled by the State Highway Department, of which V. P. Knott is State Highway Engineer, from information furnished by the various road improvement districts in the state:

Type.	Under construction, 1920. Miles.	Under construction, 1920. Est. cost, including grading and structures.	Estimated expenditures in 1920.	Approximate funds available for 1921 upon old contracts.
Earth	461	$ 1,265,000	$ 379,500	$ 400,000
Gravel	2,326	23,500,000	7,050,000	9,000,000
Macadam	451	5,000,000	1,500,000	2,000,000
Penetration	309	5,120,000	1,536,000	2,000,000
Macadam, asphaltic, concrete	300	9,225,000	2,767,500	3,600,000
Concrete	187	7,200,000	2,160,000	2,880,000
Miscellaneous expenditures, bridges, etc.	...	4,700,000	1,410,000	1,880,000
Totals	4,037	$56,010,000	$16,803,000	$21,760,000

The work on the above mileage is approximately 30 per cent completed.

The State Highway Department does not have direct charge of construction, this work being entirely in the hands of local boards. The above figures therefore should be regarded only as approximate estimates.

Colorado.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles	Av. width surfaced, feet.	Average thickness in inches.	Average cost per mile.
Grading	54	.	..	$ 9,000
Gravel surface	46	16	6	12,000
Concrete	20	18	6¾	39,000

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
Concrete	28	$3,100,000
Gravel	100	
Grading	57	

AVERAGE UNIT CONTRACT PRICES IN 1920.

Concrete bridges, per cu. yd	$28.00
Concrete pavements, per sq. yd	2.78
Common excavation, all other than rock, per cu. yd	.48
Rock excavation, per cu. yd	2.02
Earth excavation for pavement, per cu. yd	1.33

J. E. Maloney, Denver, Col., is engineer State Highway Commission of Colorado.

Connecticut.

Owing to freight and material conditions the amount of state highway construction last year in this state was very small. The following tables show the 1920 conditions and the average unit prices:

CONSTRUCTION, 1920.

Type.	Miles.	Average width. Ft.	Thickness. In.	Average cost per mile.
[illegible]	1.93	[illegible]	[illegible]	$12,000
[illegible]	17.07	[illegible]	8	16,000
[illegible]	17.70	[illegible]	7	20,000
Bit. macadam	10.30	[illegible]	2 top 7 base	40,000
Bit. concrete	7.78	18	[illegible] top 6 base	59,000
Concrete	8.45	18-20	8-6	59,000

AVERAGE UNIT PRICES. 1920.

Earth excavation, cu. yd	$1.50	Telford, sq. yd.	$1.10
Borrow excavation, cu. yd	1.50	Standard catch basin, each	75.00
Rock excavation, cu. yd	5.00	Graded, sq. yd	.80
Wet excavation, cu. yd	5.00	Gravel, sq. yd	1.10
1st class concrete, cu. yd	25.00	Macadam, sq. yd	1.70
2nd class concrete, cu. yd	15.00	3-in. bit. macadam, sq. yd.	1.20
New masonry, cu. yd	10.00	5-in. stone base, sq. yd	1.10
14-in. C. I. culvert, lin. ft.	2.50	Bit. concrete top, sq. yd	2.00
18-in. C. I. culvert, lin. ft.	3.25	Concrete base, sq. yd	1.70
24-in. C. I. culvert, lin. ft.	4.00	Concrete, sq. yd	3.40
30-in. C. I. culvert, lin. ft.	5.00		

The appropriation on the 1921 work has not yet been made by the State Legislature. Charles J. Bennett, Hartford, Conn., is State Highway Commissioner.

Delaware.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
Cement concrete	48	16	7½	$55,000
Penetration macadam	9	14	8	30,000

25% increase over 1919 cost.

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
Cement concrete	60	$3 500,000
Penetration macadam	6	

The average unit contract price last year for cement concrete pavement was $18 per cubic yard, and for excavation $1.50 per cubic yard. In 1919 the prices were $14 per cubic yard and $1.25 per cubic yard.

Owing to the fact that the program of the State Highway Department for the year 1921 is dependent, in part, upon the action of the State Legislature which is now in session, it is not possible to present a definite program for the present year. There will, however, be placed under construction approximately 20 miles of 16 ft. concrete road, completing the 98-mile boulevard constructed from the private funds of T. Coleman DuPont. In addition it is hoped to let approximately 20 miles of State Highway and 30 miles of State Aid Highway, the cost of the latter being paid for jointly by the state and counties. There remain 56 miles of roadway yet to be constructed under existing contracts. It is expected this will be completed during the coming season. New Castle County will continue and probably complete the work between Newark and Wilmington which is on the main route between Philadelphia and Baltimore. This work has been in progress for several years and is now nearing completion.

Charles M. Upham, Dover, Del., is chief engineer State Highway Department.

Idaho.

During 1919 and 1920 40 miles of paved roads, 380 miles of gravel road and 275 miles of earth road were completed in this state. The construction program for 1921 has not yet been announced. It is dependent on acts of State Legislature and Federal aid.

Illinois.

During 1920 341 miles of hard surfaced roads were completed; practically all of this construction was concrete, built under the state 1919 specifications which called for a thickness of 8 in. in the center and 7 in. at the sides. The 1920 specifications called for a uniform thickness of 8 in. throughout the entire pavement. The mileage completed during 1920 is distributed as follows:

	Miles.
Lincoln Highway	51
Dixie Highway	46
National Old Trails Road	69
Chicago-East St. Louis Road	113
Chicago-Waukegan Road	9
State Aid Work	53
	341

There are still uncompleted contracts on the above roads approximately as follows:

	Miles.
Lincoln Highway	12
Dixie Highway	20
National Old Trails Road	48
Chicago-East St. Louis Road	71
Chicago-Waukegan Road	11
State Aid Work	28
	190

In addition, contracts were awarded in 1920 for 134.95 miles of grading and 81 bridges on the Bond Issue System; involving a total amount of $3,427,070. Of these contracts, 56.77 miles of grading and 30 bridges have been completed.

A recent bulletin of the State Division of Highways has the following regarding the 1920 work:

> The completion of 341 miles of durable roads during the year is more than we anticipated could be built when we faced the car shortage and rulings of the Interstate Commerce Commission early in the season. The effort put forth by the Department and the contractors would easily have built double the mileage if conditions had been favorable. At the beginning of the season there were approximately 100 paving machines on the ground set up "ready to go" only waiting for the materials to be delivered. Not more than 53 of these equipments were in use at any one time during the season, and the average through the season was considerably under that number. This situation would indicate that double the amount of work could have been accomplished if the railways could have transported the necessary materials.
>
> The record of the year should not be closed without giving credit to the contractors who fought determinedly to complete their contracts even in the face of this discouraging situation. The public should know that the increased cost of labor and materials, as well as the intermittent supply of materials, causing the contractors to close down work for a day or a week at a time, while being obliged to keep their men on the pay roll in order that their organization should not be dissipated, has in many cases meant the absorption of all their profits and in some instances even a direct loss. The contractors should also be commended for their effort to conform strictly to the specifications of the Department in producing a road of good quality despite the unfavorable conditions with which they had to contend.

It is not possible at the present time to definitely outline the 1921 program. However, the State Division of Highways of which Clifford Older is chief highway engineer, is preparing to call for bids in the early spring, and no doubt will continue to award contracts for grading and bridge work, as well as pavement work, if conditions are favorable.

The above mentioned bulletin also gives some information regarding the outlook for the present year. We quote from it as follows:

> In November, 1918, the people approved the issuing of $60,000,000 in bonds, the proceeds of which were to be used in the improvement of a State wide system of 4,800 miles of the main highways of Illinois. Of this mileage approximately 650 miles have been improved; and 162 miles are under contract, the cost of construction to be paid out of Federal-State funds already appropriated. There remains therefore 4,000 miles of the System still unimproved. None of the $60,000,000 has been issued. In addition to the fund to be derived from the $60,000,000 bond issue, it is anticipated that Federal appropriations will be continued. These two sources will undoubtedly yield a sufficient fund to carry on the construction work for the next few years.
>
> The indications now are that building conditions are gradually improving. We can safely look for cheaper materials and a larger supply of labor at less cost, as well as an improved transportation situation. It is possible that during the coming year (1921) we may see the cost of road building decreased to prices prevailing in the spring of 1919, with a possibility of even a greater reduction in the following year. It is also the opinion of the majority of the prominent financiers of the country that within the next few months the forces now working towards a readjustment in all lines will bring about a corresponding readjustment of interest rates, which would mean the ability of the State to market its road bonds on a more satisfactory basis than at present.
>
> If the hopes of the Department are realized in these respects then a large part of the 4,000 miles still unimproved will be built during the administration of Governor-elect Small. It is well known that he favors as diligent a prosecution of this work as is consistent with sound business principles. He is ready, whenever the prices of materials have reached a satisfactory basis, to authorize the letting of contracts as rapidly as plans and specifications can be prepared for as many miles as can be built during the 1921 season.
>
> With the readjustment of general conditions, which we all confidently expect, the people of Illinois can look forward to the completion of its State-wide system within a comparatively few years.
>
> The bond issue law provides that as far as it is practically possible, work shall be carried on in the different sections of the State at the same time. It is needless to say that this plan will be put into effect; and that the construction of the bond issue roads will be scattered generally over the State; however, looking towards connecting the 1921 work as rapidly as possible with the roads already completed. This must be done in order to give the people the greatest benefit within the shortest space of time. Outside of the provisions of the bond issue law, it is desirable, owing to transportation facilities, to scatter the work in order to bring into use in the handling of materials as many as possible of the principal railway systems.

Iowa.

In spite of handicaps due to lack of materials and shortage of transportation facilities excellent progress was made last year on road construction. The following table shows the work done to Dec. 1 on 96 Federal aid and primary road projects in 66 counties:

	Mileage in contract.	Mileage completed.
Permanent grading	972.83	549.03
Graveling	224.54	102.52
Paving	164.36	46.58
Tiling (lineal feet)	2,380,000	1,061,500

Of the above amount of permanent grading 697 miles represents permanent grading not at present under contract to be covered by any form of surfacing. The remainder of the permanent grading is in connection with paving and gravelling projects. Out of the 697 miles of earth roads under contract 309.82 miles were reported complete on December 1st.

A summary of the work of the Department of Road Administration for the year ending Dec. 1, 1920, is as follows:

Projects outlined—	
Federal aid projects	5
Primary road projects	95
Project statements approved—	
Federal aid projects	45
Primary road projects	83
Estimated cost—	
Federal aid projects	$ 8,842,425.10
Primary road projects	10,289,946.68
Federal aid requested on federal aid projects	3,455,100.00

In this connection it might be added that all federal aid projects that have thus far been submitted have been approved. It is not contemplated that any additional federal aid projects will be submitted until additional appropriations for this work have been made by Congress.

Plans and specifications for 48½ projects have been submitted to the Bureau of Public Roads. These plans contemplate improving approximately 638 miles of road at an estimated cost of $13,374,639.

Plans and specifications for 36 primary road projects have been submitted to the board of supervisors involving the improvement of approximately 325 miles of road at an estimated cost of approximately $3,690,000.

Projects agreements covering 46½ federal aid projects, involving a total mileage of 597 miles have been executed by the Secretary of Agriculture. Approximately $5,605,000 of federal aid funds have been obligated in these agreements. Incidentally, it might be mentioned that all funds that must be obligated by July 1, 1921, are already covered by project agreements, leaving until July 1, 1922, to cover the remaining funds appropriated for this work. The total amount remaining to be obligated is approximately $1,650,000.

Contracts have been awarded on 74 different projects, involving a total mileage of approximately 790 miles and a total estimated expenditure of approximately $11,500,000.

The above are the principal results secured through the Department of Road Administration during the past year. Bids are being received on a considerable amount of work for 1921 construction. Excellent competition is prevailing, particularly on grading projects. On the basis of recent bids it would appear that the 1921 grading work will be approximately 25 per cent cheaper than average prices prevailing for 1920 construction. Good competition was also secured at paving lettings. F. R. White, Ames, Ia., is chief engineer, State Highway Commission.

Kansas.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
Earth	23.8	30		......
Gravel	26.3	16 and 18	9	$15,000-20,000
Macadam	13.3	16 and 18	7½	30,000
Concrete	35.6	16 and 18	7	40,000
Brick	16.5	16 and 18	8	50,000

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.
Earth	55.6
Gravel	45.0
Macadam	24.8
Concrete	91.8
Brick	38.2

The mileage completed in 1919 was 17.67 and in 1920 97.90. The total mileage incompleted and under contract is 300.73. The following notes are from a summary of the biennial report of the Kansas Highway Commission of which M. W. Watson is State Highway Engineer, submitted Jan. 1, 1921, to the State Legislature.

> During the past two years the highway program has been subjected to one delay after another, until out of a mileage of 357.881 placed under contract it has been impossible to complete more than 100 miles. The delays are chargeable to three primary reasons: first, lack of adequate rail transportation for materials; second, the shortage of materials; third, labor difficulties.

The first reason is the one that [illegible] in building highways than the other two combined. The Interstate Commerce Commission since the railroads left Government control has been issuing priorities and restrictions which have operated against the highway work in almost every instance, and even when special permission was granted to furnish equipment for hauling of materials for certain work it has been withdrawn shortly after permission was granted. As a large part of the material entering into our highway program must be shipped by rail it has proven unusually difficult to carry on our program during the past two years.

Second. Highway work has increased more rapidly during the past few years than has the production of materials required for highway construction so that the demand for material exceeds our present available supply. There are undoubtedly many natural resources that have as yet been undeveloped which will eventually assist in carrying on the program and every facility should be provided for the investigation of our resources with a view to their commercial development.

Third. Labor conditions have affected the highway program as well as other industries. Labor has been rather shiftless and inclined to be indifferent towards the work. Delays in receiving material requiring temporary discontinuance of work has usually caused the contractor to lose the bulk of his force. The necessity of reorganizing upon again starting work not only delayed the work, but increased the cost.

Several other reasons have been responsible for a part of the delay, such as: shortage of contractors properly equipped and trained in this work, financial difficulties and weather conditions during the past season, but none of these have had the effect of the three first mentioned. The weather has been unusually bad for highway work during the past season, but had the material been available at the proper time much more work could have been accomplished. Many of our contractors have had no experience in country highway construction; and, although experts at city work, have been unfamiliar with the difficulties that they have encountered in the highway program so that some delay has been encountered from this source. Financing an organization has been difficult under present conditions, especially during the last six months.

Kentucky.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
Earth	101.2	20-24	.....	....
Gravel	52.1	10-16	12-18	$13,000
Waterbound macadam	110.6	14-18	7-9	27,000
Bituminous macadam	1.4	14-18	7-9	......
Rock asphalt	13.4	16-20	1½-2 top 7-9 base	34,000
Cement concrete	6.7	18-20	8 at center	43,000
Brick	2.0	16	.....	......
Cinder	1.5	10-16	.....	......
Surface treatment	100.1	14-18	.....	......
Widening old road	10.0	20-24	.....	......

The amount of $7,000,000 is available for 1921. The probable construction is as follows:

Type of road.	Miles.
Cement concrete	10.0
Bituminous or rock asphalt	60.0
Waterbound macadam	50.0
Gravel	25.0
Earth	75.0
Other types	50.0

Jos. E. Boggs, Frankfurt, Ky., is State Highway Engineer.

Maine.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
State Highways.				
Gravel	30	18	8	$16,000
Bituminous macadam	18	18	6	32,500
Concrete	...	18	7½	41,850
State Aid.				
Gravel	150	18	8	10,000

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
State Highways.		
Gravel	60	$3,500,000
Bituminous macadam	60	
Concrete	60	
State Aid.		
Gravel	175	1,500,000

Paul D. Sargent, Augusta, Me., is chief engineer, State Highway Commission.

Maryland.

In 1920 the State Roads Commission of Maryland put under construction or had left over from 1919, 162 miles of roads, which contracts were completed as follows:

Character of construction.	Under contract.	Completed
Concrete	100.43	86.45
Sheet asphalt on concrete base	2.60	2.60
Sheet asphalt on old macadam or concrete base	22.26	19.48
Waterbound macadam	7.04	6.50
Gravel	30.00	19.38

From the above, it will be seen that on Nov. 15, 1920, when the construction season ended for the winter, the state, with the exception of about 28 miles, had completed its construction program for the year, and this, despite the acute shortage of transportation, brought about by lack of railway equipment for transportation purposes. Of the 28 miles of uncompleted work, 11 miles were gravel contracts in Southern Maryland which were let very late in the construction season.

Contingent on the sale of $2,000,000 worth of state bonds in February and on securing $869,000 from the Government for Federal Aid projects, Maryland will have available in 1921, for road, bridge and maintenance, including federal, state and county work, the following funds:

Construction	$6,000,000
Maintenance	1,600,000

John N. Mackall, Baltimore, Md., is chairman and chief engineer of the State Roads Commission.

Mississippi.

The work done in 1920 is summarized in the following tabulation:

Project number.	County.	Length in miles.	Type.	Total est. cost.	Fed. aid allotted.	Fed. aid received.	Per cent complete
1	Ittawamba	23.6	14-ft. gravel	$ 129,458	$ 60,000	$ 23,060	55
[illegible]	Rankin	55.7	12-ft. gravel	53,482	26,741	4,753	45
6	Newton	13.1	Earth	51,380	25,690	25,020	100
9	Kemper	5.6	12-ft. gravel	49,326	24,663	12,549	...
10	Lincoln	6.8	16-ft. gravel	84,560	42,280	34,449	90
11	Amite	7.0	8-ft. gravel	57,958	28,979	18,893	100
13	Madison	4.2	14-ft. gravel	20,967	8,000	3,891	100
14	George	13.6	Earth	32,717	16,358	5,134	100
15	Wilkinson	9.0	12-ft. gravel	65,699	32,849	30,241	100
16	Simpson	6.8	12-ft. gravel	58,051	29,025	24,206	95
[illegible]	Hinds	4.1	9-ft. gravel	30,950	15,000	15,000	100
[illegible]	Rankin	3.7	10-ft. gravel	20,774	10,387	......	25
20	Walthall	16.4	12-ft. gravel	143,213	71,606	58,089	95
21	Lowndes	7.3	12-ft. gravel	53,160	26,580	9,355	85
22	Benton	11.8	10-ft. gravel	109,358	54,679	19,359	12
24	Marshall	6.9	10-ft. gravel	54,871	27,435	16,318	60
28	Lowndes	5.3	12-ft. gravel	76,488	38,244	11,984	33
[illegible]	Lauderdale	7.7	12-ft. gravel	61,495	30,747	12,281	..
[illegible]	Alcorn	3.2	16-ft. gravel	43,832	21,916	......	40
[illegible]	Lee	15.4	15-ft. concrete	565,587	282,793	......	02
36	Walthall	9.2	12-ft. gravel	99,513	49,756	24,612	..
40	Monroe	13.8	14-ft. gravel	133,670	66,835	18,346	50
41-A	Wilkinson	7.5	12-ft. gravel	89,617	44,808	10,188	.
[illegible]	Pike	9.7	14-ft. gravel	100,062	50,031	....	.
44	Lawrence	10.9	Earth	49,923	24,961	17,360	95
[illegible]	[illegible]	3.7	12-ft. gravel	24,236	12,118	9,348	95
[illegible]	[illegible]	11.6	12-ft. gravel	240,483	74,000	.....	
[illegible]	[illegible]	33.7	Earth	313,491	100,000	......	12
[illegible]	[illegible]	13.0	16-ft. gravel	249,172	100,000	10,715	20
[illegible]	[illegible]	6.8	12-ft. gravel	49,142	24,571	17,922	100
[illegible]	[illegible]	8.1	14-ft. gravel	129,997	64,998	..	..
77	Jackson	[illegible]	18-ft. concrete	100,544	50,272	30,865	95
[illegible]	[illegible]	3.6	12-ft. gravel	52,224	26,112	15,971	100
[illegible]	[illegible]	4.5	16-ft. gravel	80,303	40,151	......	35
84	Jefferson	35.2	12-ft. gravel	365,304	182,652	36,415	..
86	Lincoln	[illegible]	16-ft. gravel	61,214	30,607	25,885	100
93	Pearl River	12.9	16-ft. gravel	114,341	57,170	3,742	22
		369.6		$4,016,579	$1,872,757	$545,966*	...

*[illegible] Federal aid vouchers pending.

It is estimated that for 1921 there will be approximately $5,000,000 available. H. C. Dietzer, Jackson, Miss., is State Highway Engineer.

AVERAGE UNIT CON[illegible] PRICE IN 1920.

Cement concrete pavement [illegible]	3.22
Excavation (gravel surface)	0.78
Excavation (paved surface)	0.65
Gravel surface—0 to ½ mile	0.70
Gravel surface—½ to 1 mile	0.85
Gravel surface—To 1 mile p[illegible]	1.00
Gravel surface—Cubic yard [illegible]	0.45

Michigan.

The sum of $10,311,000 will be available for constructing state trunk line roads in 1921. It is proposed to construct 600 miles of this road. In addition to this road work to be put under contract by the State Highway Department there are upwards of $25,000,000 worth of work to be done by counties on non-trunk line roads.

MICHIGAN STATE TRUNK LINE ROADS.

Class.	Contracts awarded. 1917	1918	1919	1920.	Total.	Miles.x Contracts completed. 1918.	1919.	1920.	Total.	Approx. *miles completed to 1-1-21.	Approx. carried into 1921.
Culv.	....		(6)	(8)	(14)	....	(3)	(8)	(11)	.....	.....
Clear. & Grub.			8.382	17.804	26.189	..	..	1.345	1.345	.....	.....
G & DS			84.347	77.476	161.823	.	0.425	41.619	42.044	97.2	64.6
A			17.346	29.422	46.768	..	2.161	15.176	17.337	27.3	19.5
B			130.204	175.954	306.158	.	....	30.254	30.254	86.2	220.0
C			17.371	14.745	32.116	..	......	4.223	4.223	8.9	23.2
E			47.281	22.240	69.521	.	0.057	5.784	5.841	40.0	29.5
E-Bit			8.031	17.341	25.372	.	1.918	8.996	10.914	20.4	5.0
Sur. Tr				1.764	1.764	....	....	......	......	0.0	1.8
F			21.552	55.643	77.195	....	0.152	3.037	3.189	23.7	53.5
F-Bit.			3.552	12.581	16.133	..	....	4.918	4.918	4.8	11.3
F-Asp.				0.652	0.652	......	.....	0.652	0.652	0.7	0.0
F-Mis.				1.366	1.366	......	......	......	......	1.4	0.0
G				0.382	0.382	.	..	0.382	0.382	0.4	0.0
Totals	......	....	338.066	427.373	765.439	....	4.713	116.386	121.099	311.0	428.4
xNet mileage (This is total miles by contracts, some mileage covered by more than one contract)					697.919	....	....	....	113.143	275	4 3
FEDERAL AID ROADS.											
Culv.		....	(1)		(1)		(1)	....	(1)	.....	.....
G & DS		64.307	37.642	52.230	154.179	....	21.819	33.083	54.902	78.0	76.
A		....	11.875	15.635	27.510		z11.634	15.295	15.295	30.1	9.0
B		37.861	12.098	41.138	91.097	1.166	15.248	11.068	27.482	45.2	45.9
C		13.475	4.600	1.284	19.359	....	....	18.075	18.075	18.2	1.2
E	5.983	2.530	9.597	....	18.110	....	3.999	5.983	9.982	15.8	2.3
E-Bit.	....	....	....	.....	....	....	....	....	....	.....	.....
Sur. Tr.		.....		4.027	4.027	....	....	4.027	4.027	4.0	0.0
F		21.196	30.482	37.271	88.949	5.884	8.377	0.072	14.333	51.7	37.3
F-Bit.		3.215	5.285	25.158	33.658	2.000	2.618	3.882	8.500	8.5	25.2
G		......	0.385	.....	0.385	....	0.385	....	0.385	0.4	0.0
Totals	5.983	142.584	111.964	176.743	437.274	9.050	52.446	91.485	152.981	251.9	197.1
xNet mileage (This is total miles by contract, some mileage covered by more than one contract)					353.209	....	....	....	140.934	215	138
Note z—11.634 miles awarded as G & DS and surfaced by force account.											
STATE ASSESSMENT DISTRICT ROADS.											
G & DS	....	9.323	....	11.765	21.088	....	....	......	0.0	18.1	3.0
B	52.489	105.671	76.641	52.301	287.102	11.962	51.941	84.928	148.831	208.7	78.4
C	12.059	2.927	25.269	....	40.255	....	8.409	25.215	33.624	36.2	4.0
E	....	.....	24.332	5.646	29.978	......	....	13.933	13.933	14.1	15.9
Sur. Tr.	....	....		5.455	5.455	......	....	5.455	5.455	5.5	0.0
F	......	8.063	7.787	0.229	16.079	3.453	4.771	7.626	15.850	15.9	00.2
Totals	64.548	125.984	134.029	75.396	399.957	15.415	65.121	137.157	217.693	298.5	101.5
xNet mileage (This is total miles by contracts, some mileage covered by more than one contract)					392.747	....	....	....	210.482	293	100
COMBINED TOTALS. All Roads.											
Culv.	....	....	(7)	(8)	(15)	....	(4)	(8)	(12)	.....	.....
Clear. & Grub.			8.382	17.807	26.189	......	....	1.345	1.345	.....	.....
G & DS		73.630	121.989	141.471	337.090	..	22.244	74.702	96.946	193.3	143.8
A			29.221	45.057	74.278	....	2.161	30.471	32.632	57.4	16.9
B	52.489	143.532	218.943	269.393	684.357	13.128	67.189	126.250	206.567	340.1	344.5
C	12.059	16.402	47.240	16.029	91.730	.....	8.409	47.513	55.922	63.3	28.4
E	5.983	2.530	81.210	27.886	117.609	..	4.056	25.700	29.756	69.9	47.7
E-Bit.		....	8.031	17.341	25.372	......	1.918	8.996	10.914	20.4	5.0
Sur. Tr.			....	11.246	11.246	......	....	9.482	9.482	9.5	1.7
F		29.259	59.821	93.143	182.223	9.337	13.300	10.735	33.372	91.3	90.9
F-Bit.		3.215	8.837	37.739	49.791	2.000	2.618	8.800	13.418	13.3	36.5
F-Asp.				0.652	0.652	....	....	0.652	0.652	0.7	0.0
F-Mis.				1.366	1.366	....	.....	....	....	1.4	0.0
G			0.385	0.382	0.767	....	0.385	0.382	0.767	0.8	0.0
Total	70.531	268.568	584.059	679.512	1602.670	24.465	122.280	345.028	491.773	861.4	741.4
Net mileage					1440.684	....	....	....	464.559	783	661

Note *—Approximate total miles constructed under both completed and uncompleted contracts, exclusive of clearing and grubbing.

KEY.

Culv.—Culverts only (Number).
Clear. & Grub.—Clearing and Grubbing.
G & DS—Grading and Drainage Structures.
A—One Course Gravel or Stamp-sand.
B—Two Course Gravel.
C—Stone or Slag Base-Gravel Top.
E—Waterbound Macadam.
E-Bit.—Bituminous Macadam.
Sur. Tr.—Bituminous Surface Treatment.
F—Cement Concrete.
F-Bit.—Bituminous Concrete.
F-Asp.—Sheet Asphalt.
F-Mis.—Miscellaneous Bituminous Pavements.
G—Brick on Concrete Base.

The above table is a contract summary of the work for 1920.

Frank F. Rogers, Lansing, Mich., is State Highway Commissioner.

Minnesota.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
Cement concrete	59	18	[illegible]	$24,507
Asphalt concrete	19	20	8	29,777

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
Bids will be received on cement concrete, asphaltic concrete-A & B and Brick pavement..	Approximately 100 miles	Approximately $25,000,000

John H. Mullen, St. Paul, Minn., is Deputy Commissioner of Highways and chief engineer of the State Highway Department.

Montana.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Average width surfaced, ft.	Average thickness in inches.	Average cost per mile.
Graded	193.72	....	...	$ 6,715
Graveled	437.97	10 and 16	7	8,415
Concrete	28.08	18	7	40,622
Reinforced concrete	1.32	37½	6	95,840
Bituminous surface on concrete base	1.37	18	7½	51,056

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
Concrete	13.0	$640,000
Graded	40.0	270,000
Graveled	120.0	975,000
Bridges	.....	275,000

AVERAGE UNIT CONTRACT PRICE IN 1920.

Common excavation	$0.57
Intermediate excavation	0.95
Rock excavation	2.05
Gravel surfacing, cu. yd.	3.00

Class "A" concrete in bridges [illegible]
Class "B" concrete in bridges [illegible]

John N. Edy, Helena, Mont., is chief engineer, State Highway Commission.

New Hampshire.

The construction program of the State Highway Department can not be determined until the Legislature makes its appropriation

BIDDING PRICES ON STATE HIGHWAY WORK IN 1920.

	Average bid.	Average low bids.
Excavation	$1.82	$1.81
Boulder	2.12	2.00
Ledge	6.95	6.69
Run of bank gravel	3.18	2.86
Foundation course, field or quarry stone	3.96	3.62
Broken stone, tons	4.57	4.00
Surface course gravel, cu. yd.	3.00	2.63
Bottom course gravel, cu. yd.	2.78	2.53
Surface course crushed gravel	4.08	4.12
Bottom course crushed gravel	3.75	3.50
Bit. macadam broken stone	5.82	5.84
Bottom course modified asphalt	1.22	1.00
Surface course modified asphalt	1.15	1.00
Laying 12-in. C. M. P.	1.26	1.13
Laying 14-in. C. M. P.	1.43	1.49
Laying 16-in. C. M. P.	1.71	1.72
Laying 18-in. C. M. P.	1.79	1.52
Laying 24-in. C. M. P.	3.32	3.83
Laying 30-in. C. M. P.	2.94	3.66
Wood guard rail	.82	.80
Reinforcing steel	.12	.12
1st class concrete	29.57	29.20
2nd class concrete	22.48	20.90
Asphalt, gal.	.11	.09½
Sand cover for surface treatment	.042	.042
Cement stone masonry	16.00	16.00

Frederic E. Everett, Concord, N. H., is State Highway Commissioner.

New Mexico.

SUMMARY OF STATE AID AND MAINTENANCE ON ROADS AND BRIDGES, 1919 AND 1920

Kind of work.	Unit.	1919.	1920	Total.
Roads graded	Mile	$ 786.67	$ 698.49	$ 1,485.16
Roads surfaced	Mile	182.74	84.98	267.72
Roads repaired	Mile	2,792.15	8,925.01	11,717.16
Roads drained	Mile	12,757.52	22,358.15	35,115.67
Roads surveyed	Mile	298.34	124.11	422.45
Roads ditched	Mile	366.08	348.67	714.75
Roads fenced	Mile	37.25	13.80	51.05
Bridges constructed	Number	104	64	168
Culverts constructed	Number	535	481	1,016
Crossings constructed	Number	49	26	75
Bridges repaired	Number	179	323	502
Culverts repaired	Number	230	658	888

Principal items of work only are shown. Construction of cattle guards, resurfacing of roads, etc., are not included.

The figures shown in Table I are preliminary estimated cost plus 10 per cent for engineering and contingencies in all cases. The projects under construction show actual cost plus 10 per cent. Since compiling the above tables the following projects were let in December 1920 at prices shown below. Reduction due to falling labor, feed and material prices. No. 22—$145,801.70; No. 23—$37,039.87; No. 28—$235,499.11; No. 42—$21,838.41. L. A. Gillett, Santa Fe, N. Mex., is state highway engineer.

New York.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Av. width surfaced, feet.	Average thickness in inches.	Av. cost per mile.
Concrete	84.26	*	Approx. 6	$36,560
Bit. macadam	64.90	14	Approx. 10	28,831
Water bd. mac.	23.47	14	9	†
Gravel	3.95	16	7½	*

*90% of mileage 16 ft.; small lengths in village as high as 56 ft. †The accurate cost can be obtained per mile, as they are completion contracts.

The amount available for construction in 1921 is $26,000,000. Frederick S. Greene, Albany, N. Y., is state highway commissioner.

TABLE I—FEDERAL AID CONSTRUCTION IN NEW MEXICO.

Project number.	County	Length, feet.	Type of surfacing.	Stage.	Total cost.	Cost per mile.
1-A	Colfax	9.357	Crushed stone	Construction 100%	$ 153,795	$16,436
1-B	Colfax	14.370	Gravel	Construction 95%	157,492	10,959
1-C	Colfax	14.500	Gravel	Plans 90%	179,166	12,356
1-D	Colfax	12.0	Gravel	Statement 100%	36,383	3,031
3	Santa Fe	9.320	Crushed stone	Construction 100%	101,472	10,887
4	Valencia	20.620	Gravel	Construction 80%	116,117	5,631
5	Quay	21.231	Gravel	Construction 100%	149,105	7,023
8	Chaves	6.490	Crushed stone	Construction 100%	72,500	11,171
11	Lincoln	5.406	Gravel	Construction 100%	51,221	9,474
12	Chaves	13.212	Gravel	Construction 90%	148,375	11,230
13-A	Valencia	10,859	Crushed stone	Construction 70%	91,404	8,417
13-B	Valencia	16,423	Gravel	Plans 90%	72,500	4,414
14-A	Santa Fe	2,736	Grading only	Plans 90%	1,625	593
14-B	Santa Fe	8,258	Grading only	Construction 95%	49,735	6,022
15	Dona Ana	11,680	Concrete	Construction 100%	290,000	24,828
16	Lea	5,441	Caliche	Construction 100%	44,587	8,194
18	Eddy	32,411	Grading only	Construction 50%	107,172	3,306
19	Luna	11,676	Gravel	Construction 98%	62,782	5,377
20-A	Lincoln	2.790	Gravel	Construction 100%	28,800	10,322
20-B	Lincoln	5,090	Gravel	Construction 100%	50,535	9,928
21	Taos	8,000	Crushed stone	Statement 100%	96,000	12,000
22	Guadalupe	17,980	Gravel	Plans 100%	170,000	9,454
23	DeBaca	8,747	Gravel	Plans 100%	46,000	5,258
24	Roosevelt	11,365	Caliche	Plans 100%	106,902	9,406
25	Curry	15,437	Caliche	Construction 100%	100,377	6,502
26	Bernalillo	9,563	Concrete	Construction 75%	313,546	32,787
27	McKinley	22,422	Gravel	Plans 100%	188,100	8,389
28	Grant	13,812	Concrete	Plans 100%	265,000	19,186
29	Eddy	21,000	Gravel	Plans 90%	89,487	4,261
30	Lea	42,000	Grading only	Plans 50%	53,075	1,263
31	Sierra	3,902	Gravel	Construction 85%	23,206	5,947
32	San Miguel	15,084	Crushed stone	Construction 35%	155,218	10,290
33	Mora	12,706	Crushed stone	Construction 40%	193,895	15,260
34-A	Rio Arriba	3,181	Gravel	Plans 100%	30,000	9,431
34-B	Rio Arriba	11,919	Gravel	Construction 20%	105,590	7,402
35	San Juan	17,000	Gravel	Survey 100%	51,620	3,036
36	Sandoval	5,871	Gravel	Plans 100%	43,848	7,468
39	Quay	0.36	None	Construction 30%	137,497	381,936
40	Otero	6,500	Gravel	Plans 90%	15,031	2,310
41	Otero	18,000	Caliche	Plans 100%	57,710	3,206
42	Socorro	17,157	Gravel	Construction 10%	55,778	3,251
43	Torrance	15,981	None	Plans 100%	26,000	1,626
44	Hidalgo	8,000	Gravel	Construction 20%	44,508	5,563
45	Luna	5,599	Gravel	Construction 5%	43,780	7,819
46	Santa Fe	0.572	Gravel	Construction 100%	10,780	18,847
47	Grant	15,228	Gravel	Construction 60%	131,335	8,624
48	Chaves	15,000	Gravel	Plans 40%	128,342	8,556
49	Otero	11,572	Caliche	Construction 10%	47,246	4,082
50	Luna	15,030	Gravel	Plans 90%	72,338	4,812
51	Socorro	10,500	Gravel	Plans 90%	52,514	5,007
[illegible]	Socorro	11,300	Gravel	Plans 10%	70,466	6,235
53	Torrance	[illegible]	None	Plans 10%	70,903	1,969
[illegible]	Hidalgo	35,000	Grading only	Statement 100%	99,645	2,847
[illegible]	Grant	4.25	Gravel	Statement 100%	38,502	4,059
[illegible]	Grant	[illegible]	Gravel	Statement 100%	116,231	12,702
57	Chaves	12.75	Gravel	Statement 100%	89,100	6,988
[illegible]	[illegible]	55.7	Grading only	Statement 100%	119,627	2,147
[illegible]	[illegible]	54.0	[illegible]	Survey 15%	142,841	2,645
[illegible]	[illegible]	21.7	[illegible]	Survey 35%	108,055	4,979
[illegible]	[illegible]	5.5	Concrete	Statement 100%	162,002	29,455
[illegible]	[illegible]	4.3	Concrete	Statement 100%	118,635	27,589
[illegible]	[illegible]	12.0	Caliche	Statement 100%	92,803	7,733
[illegible]	[illegible]	12.1	Crushed stone	Statement 100%	92,035	7,607
[illegible]	[illegible]	12.9	Crushed [illegible]	Plans 100%	68,200	5,286
[illegible]	[illegible]	[illegible]	Gravel	Plans 100%	10,576	3,525
[illegible]	[illegible]	[illegible]	Concrete	Plans 100%	20,251	49,879
		903,764			$6,239,384	

North Dakota.

ALL PROJECTS, INCLUDING "FEDERAL AND STATE AID PROJECTS" AND "STATE AID PROJECTS."

	1917-1918.	1919.	1920.
Federal and state aid work completed	160.0 miles	231.2 miles	190.1 miles
Payments made to contractors on above work	$225,083.21	$571,139.22	[illegible]

	Miles.
Additional work under contract and to be completed in 1921	[illegible]
Additional work to be advertised in 1921 (approx.)	[illegible]
Additional work "on books" for 1922 (approx.)	[illegible]
Total of completed and contemplated work (approx.)	[illegible]

STATUS ON DEC. 31, 1920, OF "FEDERAL AND STATE AID PROJECTS."

	Miles.	Total cost.
Project agreements executed	600.2	[illegible]
Additional project agreements requested	208.3	[illegible]
Subtotal	808.5	[illegible]
Preliminary estimate projects for which agreements are to be requested in 1921	568.0	[illegible]
Total	1,376.5	[illegible]

W. H. Robinson, Bismarck, N. Dak., is chief engineer and Secretary of the State Highway Commission.

Oregon.

Under the several authorized bond issues, there remains unsold a total par value of $13,066,799. Of this amount, $12,683,417 will be available during 1921 and 1922. This $12,683,417, it is estimated, will net approximately $12,000,000, which, together with the estimated net income from the quarter-mill tax, motor vehicle license fees, gasoline tax and all other sources of revenue, including federal government and county co-operation, will give during the years 1921 and 1922 a total amount available for expenditures for road purposes, under the supervision of the Highway Commission, of approximately $24,900,000. Of this amount, there is obligated in connection with outstanding contracts, maintenance work, and general operating expense, a total of approximately $14,800,000. This leaves available for new contracts during the 1921-22 biennium, approximately $10,100,000.

In this connection it should be noted that during the 1919-1920 biennium, contracts were awarded by the Commission to the amount of $26,200,000, which amount is more than two and one-half times as great as the amount available for contracting during the coming biennium.

Of the $24,900,000 estimated to be available for expenditure during 1921 and 1922, $19,650,000 is state money, $3,000,000 is Federal Government money, $2,200,000 is county money, and $50,000 is railroad money. The amounts of county and railroad money include only funds which have been definitely agreed to by the authorities concerned, and do not include any amounts for anticipated future co-operation.

During the 1919-1920 biennium there were awarded contracts for 419 miles of paving, 638 miles of broken stone and gravel surfacing, 1,000 miles of grading and 162 bridges. Of this work there remained uncompleted on Nov. 30, 1920, 72 miles of paving, 269 miles of broken stone and gravel surfacing, 239 miles of grading and 55 bridges, including forest road projects. The total estimated cost of all work placed under contract is $28,500,000. Upon this work there has been expended approximately $18,750,000, leaving a total obligation under uncompleted contracts of approximately $9,750,000.

Herbert Nunn, Salem, Ore., is state highway engineer.

Pennsylvania.

CONSTRUCTION, 1919 AND 1920 CLASSIFIED ACCORDING TO TYPE.

Type.	Miles 1919.	Miles 1920.	Total miles.
Reinforced concrete	170.07	325.64	495.71
Plain concrete	5.30	1.14	6.44
Bituminous top concrete base	21.31	58.46	79.77
Brick	20.24	17.42	37.66
Sheet asphalt	28.49	1.93	30.42
Macadam	7.37	9.28	16.65
Total	252.78	[illegible]	666.65

W. D. Uhler, Harrisburg, Pa., is chief engineer State Highway Department.

Rhode Island.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Av. width surfaced, feet.	Average thickness in inches.	Av. cost per mile.
Bit. macadam	15	18+	8*	$42,000†
Bit. concrete	22	18+	8*	37,000†
Concrete	3	18+	6½-8½*	50,000†

*Thickness is exclusive of gravel "insulating" cushions and stone fill over bed subgrades, which is very common practice here.
†Includes land damages, engineering, grading, etc.

AVERAGE UNIT CONTRACT PRICE IN 1920.

	Per cu. yd.
Earth excavation	$ 1.42
Ledge excavation	3.95
Stone fill (foundation)	2.93
Concrete masonry	24.60
Road concrete, 1-2-4	14.00

It is not possible at this time to outline construction program for 1921. The funds will not be available until the legislature now in session makes appropriation. This probably will be next month or in March. Irving W. Patterson, Providence, R. I., is chief engineer State Board of Public Roads.

Tennessee.

A total of 247.69 miles of rock asphalt, bituminous macadam, waterbound macadam and concrete pavements were constructed in 1920. The total cost was $6,122,329. The probable construction for 1921 involves 300 miles, mostly bituminous macadam or rock asphalt. Approximately $7,500,000 will be available. W. P. Moore, Nashville, Tenn., is state highway engineer.

Texas.

Up to Dec. 1, 1920, there had been completed 115 state and Federal Aid projects in 49 counties of Texas. These completed projects involve a total mileage of 976.59 miles at a cost of $5,396,327 and state and Federal Aid to the extent of $904,252 and $1,308,542 respectively. Of the 976.56 miles 7.1 miles are concrete pavement; 173.94 miles gravel and crushed stone with bituminous treatment or topping; 516.06 miles gravel or crushed stone; 169.93 miles sand clay or shell; 109.56 miles of grading and concrete drainage structures, and 5 bridge projects.

There are also carried over into the 1921 construction program 174 projects that are under contract and are in various stages of completion. These 174 projects total 2,039.4 miles, have a total contract cost of $23,277,290 and involve $8,050,256 Federal Aid and $1,437,288 state aid. Of the 2,039.4 miles 100.3 miles are concrete pavement; 410.6 miles gravel or crushed stone with bituminous treatment or topping; 1,159 miles crushed stone or gravel; 77.6 miles sand clay or shell; 291.9 miles of grading and concrete drainage structures and 6 bridge projects.

In addition to the above completed projects and those under construction there are 95 projects whose plans, specifications and estimates have been approved or are being prepared, and which will be under contract in the near future or before 1922. These 95 projects involve 47.8 miles of concrete pavement; 303.7 miles of crushed stone or gravel with bituminous topping; 581.7 miles of crushed stone or gravel; 70.6 miles of sand clay or shell; 52.2 miles of grading with concrete drainage structures; and 12 bridge projects, making in all a total of 1,066.0 miles, the total estimated cost of same being $15,042,833.74. Federal Aid to the extent of $5,177,206 and $1,827,850 respectively have been granted to this work.

SUMMARY OF TEXAS STATE AND FEDERAL AID PROJECTS TO DEC. 1, 1920.

Exhibit.	No.	Miles.	Total costs.	Federal Aid.	State Aid.
Projects completed	115	976.59	$ 5,326,327	1,308,542	904,252
Projects under const.	174	2,039.4	23,277,290	8,050,256	1,437,288
Additional proj. plans approved	32	298.9	5,737,246	1,947,396	......
Add. proj. statements approved	47	590.8	7,923,115	2,366,161	390,562
Add. proj. statements pending	16	176.3	2,382,422	863,649	....
Total active projects	384	4,081.99	$44,716,502	$14,536,005	$2,732,103
Additional propects on which state and federal aid are allotted but applications incomplete				1,564,399	1,346,247

	Completed.	Under const.	Plans being prepared.
Miles concrete pavement	7.1	100.3	47.8
Miles bituminous pavement	173.94	410.6	313.7
Miles crushed stone or gravel	516.06	1,159.0	581.7
Miles sand clay or shell	169.93	77.6	70.6
Miles grading and bridges	109.56	291.9	52.2
Total mileage	976.59	2,039.4	1,066.0
Number of bridge projects	5	6	12

Rollen J. Windrow, Austin, Tex., is state highway engineer.

Washington.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Av. width surfaced, feet.	Average thickness in inches.	Av. cost per mile.
Concrete	112	20	7	$35,000

PROBABLE CONSTRUCTION IN 1921.

Type of road.	Miles.	Amount available.
Concrete	140	$6,500,000

AVERAGE UNIT CONTRACT PRICE IN 1920.

Earth excavation	[illegible]
Loose rock	[illegible]
Solid rock	[illegible]
Clearing	[illegible]
Grubbing	[illegible]

James Allen, Olympia, Wash., is state highway commissioner.

West Virginia.

Type of road.	Miles.	Av. width surfaced, feet.	Average thickness in inches.	Av. cost per mile.
Earth	254	.	.	....
Gravel	18	16	12	$ 8,000
[illegible]	62	16	[illegible]	19,000
Concrete	95	16	[illegible]	31,000
Brick	17	16	7	17,000
Asphaltic concrete	6	16	[illegible]	43,000

The road work in West Virginia at the present time is being changed from a county system to a state system. The details of the state system are not as yet worked out, but are dependent upon the action of the State Legislature, now in session.

The details of work for 1921 have not been decided but there are about $6,000,000 available of county money.

C. P. Fortney, Charleston, W. Va., is chairman State Road Commission.

Wisconsin.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles	Av. width surfaced, feet.	Average thickness in inches.
Earth	623	..	...
Gravel (all types)	624	18	6 ctr.
Top soil	126	16	8
Concrete	88	18	7 and 8

The construction program for 1921 includes 245 miles of 18 ft. wide 7 in. and 8 in. thick concrete pavement, and a considerable mileage of other types of pavement. The total construction funds available are estimated to be $20,000,000. A. R. Hirst, Madison, Wis., is state highway engineer.

Wyoming.

HIGHWAY CONSTRUCTION IN 1920.

Type of road.	Miles.	Av. width surfaced, feet.	Average thickness in inches.	Av. cost per mile.
Concrete	2.0	16	6½	$39,000
Bitulithic	1.1	24	7	71,000
Gravel	80	16	6½	8,500
Earth	700	24	...	4,000

PROBABLE CONSTRUCTION IN 1921.

Type of road	Miles	Amount available.
Concrete (20 ft. surface)	1.3	[illegible]
Concrete (10 ft. surface)	3.0	55,000
Gravel	100.0*	
Earth	300.0*	

*Funds not yet available.

AVERAGE UNIT CONTRACT PRICE IN 1920.

Earth excavation and embankment	$ 0.46
Concrete in structures	37.00

Z. E. Sevison, Cheyenne, Wyo., is state highway engineer.

Road Construction in Alaska.—During the 16 years existence of the Alaska Road Commission 1,031 miles of wagon road, 636 miles of sled roads and 3,223 miles of trail have been constructed and maintained at a cost of about $5,500,000. The annual cost of maintenance of routes in Alaska varies considerably with the locality, the range of climate being greater than that of the United States and the cost of labor also varying greatly. The experience of the Road Commission, according to an article by Maj. James Gordon Steele, president of the commission, in the January-February Military Engineer, indicates that for all Alaska proper, average construction and maintenance costs, including bridges, are about as shown in the following table:

Classification.	Cost of construction per mile.	Annual maintenance.	Total cost per mile, 1905-1920.
Wagon roads	$2,500*	$250*	$4,300
[illegible]	200	[illegible]	[illegible]
Trails	100	10	125

*For earth roads only. Higher classes of construction cost more but have proportionately much less maintenance charges. As the mileage increases, the total maintenance charges increase, so that smaller proportionate amounts are available each year for new con-

Traffic Increase Follows Improvement of Road.—That increase in traffic follows road improvement is shown by traffic census records on the road between Toronto and Hamilton, Canada. Before being paved 526 vehicles traveled the most heavily traveled section in one day. Daily average traffic today is 3,000 vehicles. As many as 400 heavily laden trucks have been counted on this road in single day.

Considerations in Design of Pavements for Heavy Traffic*

By PREVOST HUBBARD,

Chemical Engineer, The Asphalt Association, New York.

The load carrying capacity of any type or design of pavement must of necessity be influenced by the support afforded the pavement from below. Such support is furnished by that portion of the earth directly below the pavement, known as the subgrade. The supporting value of natural subgrades varies enormously as illustrated by the two extremes of muck or quicksand and solid rock. Most subgrades consist of soil lying between the extremes mentioned but still varying greatly in supporting value depending not only upon type but upon their moisture content, and degree of compaction. With very few exceptions any well compacted soil will of itself support the heaviest conceivable traffic if its moisture content is properly controlled and if it is protected by a structure which prevents the displacement of particles at its surface. The protective structure termed the pavement will then need to be only of sufficient thickness to afford such protection and at the same time itself withstand the various destructive agencies of traffic. For a given traffic this thickness will depend largely upon the type of pavement used.

The bearing capacity of most soils, particularly the clayey types, decreases as their moisture content increases above a certain point. Although there is much yet to be learned regarding the comparative bearing value of soils this fact is generally recognized and various drainage methods are employed to control the moisture content of the subgrade. Proper drainage is the first essential for maintaining a dry subgrade and measures taken to prevent access of water to the subgrade directly below the pavement are often more important than measures designed to remove accumulations of water in the subgrade. Some soils are so persistently retentive of moisture once absorbed that it is impossible to remove it with sufficient rapidity by any ordinary system of drains. Certain clayey soils belong to this class and when all practical preventive measures in the way of drainage are apt to prove inadequate it may well be advisable to modify the character of the subgrade material. Thus at relatively low cost a clay subgrade may often be greatly improved by mixing it with sand in exactly the same manner as in the construction of a sand clay road. Such a mixture will not only retain less moisture than the clay but will possess a much higher supporting value than moist clay.

It is now generally admitted that in the past too little attention has been paid to drainage in the construction of pavements outside of municipalities. At the same time there exists a marked tendency to increase the massiveness of design to a point far beyond that which is at present proving entirely satisfactory for heavy traffic in municipalities and in other places where subgrade conditions are favorable. This matter should receive the most careful consideration of engineers as it points not only to the most logical but also the most economical solution of the design of pavements It is evident that in many cases it will cost far more to increase the thickness of a pavement to such an extent that it will distribute the load sufficiently to enable a poor subgrade to support it than it would be to change natural subgrade conditions so as to create a high supporting value for the relatively thin pavement.

The widespread use of rigid pavements or pavements with rigid foundations has been largely responsible for this trend in paving design through too great dependence upon the bridging value of such rigid types, and right here exists a rather anomalous situation, for while many claims are made of the bridging value of rigid pavement it is generally admitted that careful preparation of the subgrade is necessary to uniformly support these rigid types. As a matter of fact no practicable design of highway for modern heavy traffic permits the assumption of more than a temporary bridging action over appreciable areas of a weak subgrade.

In pursuing a policy upon which general attention has once been centered many who are interested in highway construction are apt to overlook the experience of others following different lines of development and fail to profit by their experience. One of the most striking examples of this has to do with the flexible type of construction as represented by the asphalt base pavement and this in spite of a number of valuable papers and discussions upon the subject by leading engineers. Citations of past and present experience in localities other than that of interest to the individual engineer apparently carry little weight once the majority concentrate on a given line of development, and it is difficult to focus attention on any other line for the time being. To state that considerably over 12,000,000 sq. yd. of asphalt base pavements are now giving satisfactory service in California and Oregon, many of them 5 in. or less in total thickness and subjected to heavy motor truck traffic, and that some of these pavements have been in service for over 20 years with little or no cost for maintenance, should at least arouse some degree of interest on the part of eastern engineers. To further state that in such cities as Washington, D. C., Chicago, Omaha, Pittsburgh, Buffalo and Denver there are in existence sections of bituminous base which have given satisfactory service for over 20 years, should also serve to dispel any illusion that the serviceability of this type is restricted to any given locality. Service results should in themselves be conclusive, but explanations of such results are sometimes required before their full significance is grasped. It is true that theories have been advanced but these have not been backed up by test data in such a way as to make them convincing. Some degree of cushioning effect under traffic has been claimed and admitted for the asphalt base as well as the wearing course, but few engineers have believed that a mineral aggregate cemented together with asphalt could possibly possess any degree of slab strength or beam strength at least to an extent comparable with the rigid type of construction.

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*Paper presented Dec. 21, 1920, before the Engineers' Club of Philadelphia.

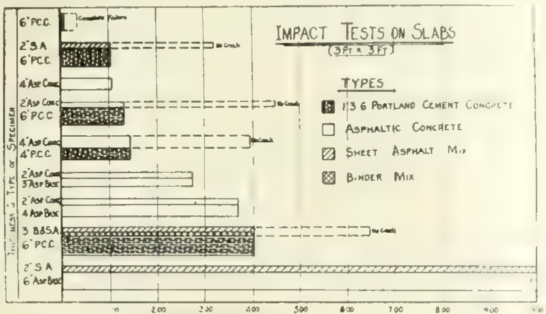


Fig. 1—Results of Impact Tests for Slabs.

Investigation to Determine Relations Between Rigid and Flexible Types.—With this in mind an investigation was begun under the direction of the writer, assisted by W. E. Rosengarten, Traffic Engineer of the Asphalt Association, to determine certain relations that exist between the rigid and flexible types of construction. Fortunately, through the very valuable work of the U. S. Bureau of Public Roads, it has already been proven that impact and not dead load is the most destructive traffic factor to be taken into account in the design of modern highways. It was therefore decided to limit these investigations to a study of the effect of impact upon test specimens having thicknesses equivalent to those commonly used in the construction of highways. It was clearly realized in advance that it would be impossible to duplicate all of the variable conditions under which impact is delivered to a pavement by traffic and it was therefore decided to confine this study to the effect of pure impact as delivered by an iron ball falling from a relatively small height.

The following description of tests will be brief both because of the limited time available for the presentation of this paper and because the results here reported are only a portion of those included in a more comprehensive investigation involving other comparisons which will shortly be presented in a detailed article.

In order to obtain comparisons at two extremes of conditions it was decided to construct and test slabs of various design upon a solid uniform subgrade and to test beams of the same design supported only by knife edges. A plot of ground was secured and upon this was laid a 6-in. course of cinders thoroughly compacted by rolling. Slabs 3 ft. square were constructed directly upon this subgrade except that after the forms had been placed the subgrade within the forms was leveled up with a very thin layer of sand so that each specimen would have a uniform thickness throughout. Portland cement concrete slabs were cast 4 and 6 in. thick of a 1:3:6 mix. These were cured under a cover of moist sand after they had set. Some of the concrete slabs were then covered with from 2 to 4 in. of coarse graded aggregate asphaltic concrete and some with sheet asphalt with and without a binder course. In addition slabs were constructed of asphaltic concrete base mixture and covered with either asphaltic concrete surface mixture or with sheet asphalt so as to produce total thicknesses directly comparable with the Portland cement concrete base specimens. At the same time corresponding sets of beams 4 ft. long and 10 in. wide were constructed of the same type and thickness. In general the specimens were treated when the concret was 28 days old although in a few cases they were slightly older when for one reason or another it was found impossible to keep up with the testing schedule which had been planned.

Method of Making the Tests.—All slabs were tested where they had been cast by means of a machine which was designed and operated so as to drop a 125 lb. iron ball upon the center of the upper surface from a height of 6 in. at the rate of about 30 blows per minute. In all cases a specimen was considered to have failed when the first crack appeared. Cracks in the Portland cement concrete were invariably first noted developing on one or more sides of the specimen from the plane of contact with the subgrade. Under continued impact these cracks traveled to the upper surface of the monolith and then across the upper surface toward the center. The all Portland cement concrete specimens broke into two to four large fragments shortly after the first crack appeared, while similar slabs with an asphalt top showed no cracking of the top after the base had failed. The results obtained on check specimens were in some cases erratic, in others, quite close together. By averaging results however the general trend is apparent and is closely borne out by results obtained on the beam specimens.

The accompanying diagram, Fig. 1, shows the resistance to impact of the various types of slabs as measured by the number of blows required to produce failures. The dotted extensions of the asphalt tops on slabs with a Portland cement concrete base show the number of blows at which the test was stopped, no failure of the top then being apparent.

The beams were tested upon steel knife edges 3 ft. apart with the same machine used for testing the slabs but with a 50 lb. iron ball dropped from a height of 1½ in. at the center of the span at the rate of about 50 blows per minute. The number of blows required to produce the first crack was recorded as point of failure. In all beam tests complete failure occurred within a very few blows after a crack appeared. The results of these tests are shown in the diagram, Fig. 2, in the same manner as the slab tests.

In considering these diagrams no attempt will be made to draw conclusions based upon a comparison of absolute values as here shown. In fact it is frankly admitted that such a course would be unwise until much more test data is available. It is believed however that the general similarity in trend of the results obtained in both the slab and beam tests is highly significant and points to interesting facts. What is clearly apparent for conditions under which these specimens were tested may be summed up as follows:

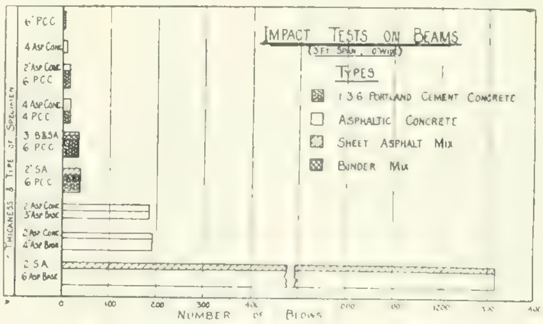


Fig. 2—Results of Impact Tests for Beams.

Asphaltic mixtures develop very decided slab and beam strength as measured by their resistance to impact. The all asphalt type of slab and beam appears to offer considerably more resistance to impact than an equivalent thickness of 1:3:6 Portland cement concrete considered either as an integral structure or as a base for an asphaltic top.

It is recognized that unsupported by practical service results deductions drawn from these tests might not be conclusive as applied to the design of highways for heavy traffic. They do, however, help to explain the remarkably satisfactory service record of the millions of square yards of 4 and 5 inch asphaltic concrete pavements in California and Oregon and point the way to a more rational development in the design of highways in other localities. In summing up the substance of this paper there are a few points which the writer wishes to emphasize:

Conclusions.—Any rational design of highway should take into account the fact that the subgrade must ultimately take the weight and shock of traffic as transmitted through the pavement and practically any reasonably dry subgrade will do this if it is compacted and its surface is protected from displacement. Careful attention to subgrade preparation and drainage is therefore the first essential to be considered.

The asphaltic concrete pavement is highly resistant to impact which is recognized as the most destructive traffic factor and under impact, develops as a single unit relatively high slab and beam strength.

It is manifestly uneconomical if not impracticable to adopt a design of highway which will permanently bridge appreciable areas of weak subgrade. While the asphalt type develops bridging action to an appreciable extent it will of itself constantly seek to maintain contact with the subgrade at all points and thus reinforce itself with the maximum supporting value of the subgrade. The rigid type of pavement or base cannot do this because of its inherent characteristics. It is therefore almost sure to crack eventually where appreciable areas of subgrade fail to support it uniformly.

Both the service history of asphalt base pavements and the test data here presented indicate that under given conditions it is not necessary to adopt as massive a design for the flexible type of base as for the rigid type. It is difficult for engineers who have had no opportunity to observe the asphalt base pavement under heavy traffic to think of it in terms of less thickness than the rigid base but in the light of present experience such consideration appears to be entirely warranted.

1920 Maintenance Costs on Primary Road System of Iowa

The maintenance of the primary road system in Iowa was performed and paid for by the individual counties from county funds until July 1, 1920. On that date the maintenance came under the supervision of the State Highway Commission. While the work was actually done and paid for by the individual counties, a 100 per cent refund was made to them from the state primary road fund, which is derived from automobile licenses. The expenditures from Jan. 1, 1920, to Dec. 31, 1920, were as follows:

Class of road.	Mileage.	Total expenditure.	Average expenditure per mile.
Earth	5,760.0	$1,292,974.51	$224
Gravel	792.3	288,553.69	364
Paving	66.8	12,125.93	181
Total	6,619.1	$1,593,654.13	$241

This item of $12,125.93 under paving includes $6,820 expended for the reconstruction of defective pavement and for the construction of guard rail, which should legitimately be charged to construction. Deducting this amount, the average expenditure per mile of paving was $79. The total expenditure is also classified as follows:

Class of expenditure	Total amount	Average per mile.
Patrol	$ 811,933.72	$123
Gang	581,653.11	88
[illegible]	52,013.36	8
Equipment and tools	148,053.94	22
Total	$1,593,654.13	$241

Reports have been received from 81 counties on the expense of marking the primary road system. In these counties the total expenditure on 5,514.3 miles of primary road was $26,719.88, or an average of $4.85 per mile. W. H. Root is engineer road maintenance of the Iowa State Highway Commission.

[illegible] ice Connections in State Road Work.—Iron conduits for water and gas mains, states the Service Bulletin of the Iowa Highway Commission, will be laid every 200 ft. hereafter by the New Jersey State Highway engineers under all state highways built through municipalities to provide against the tearing up of the pavement slabs to install these pipes where the building of new houses makes such action necessary.

Maintenance Costs for Illinois Highways

The total expenditure in 1919 for the maintenance of 980 miles of state highways in Illinois was $130,826, according to Highway Bulletin No. 5 issued in December by the Illinois State Division of Highways. Of this total $77,879 was for maintaining this wearing surface and $52,947 for maintaining earth shoulders, cutting weeds and cleaning out ditches and culverts. The following table and comments are reprinted from the bulletin:

SUMMARY OF MAINTENANCE COSTS FOR ILLINOIS HIGHWAYS IN 1919; ALL WIDTHS, 10 FT. TO 18 FT.

Type.	Miles.	Wearing surface. Av. cost per mile	Upkeep of roadsides, etc. Av. cost per mile	Total maintenance. Av. cost per mile.
Brick	[illegible]	[illegible]	$76.16	$118.79
P. C. concrete	366.15	54.05	95.81	149.86
Bit. concrete	19.43	244.75	11.88	256.13
Bit. macadam	24.02	254.01	73.67	327.68
W. B. macadam	[illegible]	296.45	35.35	331.80
Gravel	42.36	129.24	25.74	154.98
Oiled earth	[illegible]	60.37	21.13	81.50
Earth	280.75	76.69	15.61	92.30

The cost of maintaining the earth shoulders, cutting weeds and cleaning out ditches and culverts is of course not affected by the type of pavement and normally is the same for all types of roads. In the table is shown separately the cost of maintaining the earth shoulders and ditches and the cost of maintaining the paved surfaces. The combined cost is also shown. These figures are for the year 1919, the 1920 costs not having been tabulated. In some instances the 1920 costs will exceed the 1919 costs because of the higher costs of material and labor and the necessity for repairing breaks in all types of pavement due to excessive loading. In 1920 these extra expenses will be a matter of separate record.

It is of course evident that average maintenance costs should not be considered conclusive as the location of the road and its use by truck traffic largely determines the maintenance costs.

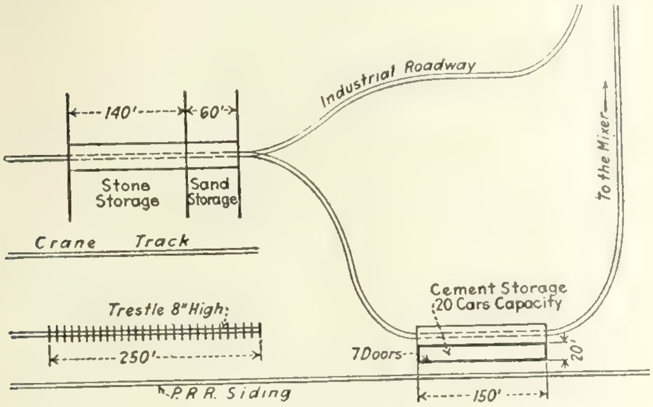
It should also be understood that a 1-year record of the maintenance cost of any particular type of construction is not necessarily a measure of the economic service value of that type. This is true because of the fact that certain types of road—such as bituminous macadam—may require but very little maintenance expenditures during one season, and the following season it may be necessary to give the road a surface treatment at very considerable cost in order to preserve its integrity. This is not only true for the type of road mentioned, but is more or less true for all types. Further, if a certain type of pavement designed for, and used by, light traffic for a number of years is suddenly called upon to bear heavy motor truck traffic, the pavement may be utterly destroyed; and must be replaced by an entirely different type to resist the altered traffic. The reconstruction is not ordinarily classed as maintenance but as new construction. This of course may lead to a misconception of the service rendered by a given type of pavement. Further; if but a small mileage of a given type of pavement is under maintenance, an unusually large maintenance expenditure on a given section may cause the average for that type of pavement for one year to appear abnormally high, or on the other hand the location of the roads built of any one type may be such that the total mileage of such type may be subjected to unusually light traffic and the maintenance therefore appear abnormally low.

Lines to Guide Traffic at Street Corners and Curves.—In order to minimize the danger of collisions between vehicles at corners and curves of streets in the Ancon-Balboa district of the Panama Canal Zone, the Division of Municipal Engineering has painted 4-in. white guide lines on the surface of the roadway at such places. The line begins in the center of the road at a point well beyond the beginning of the curve, and extends to the corresponding tangent beyond the curve. Drivers are required to keep to the left of the line while passing it, except at cross roads and T-junctions, where additional lines indicate the track to be followed in crossing over the line to make the turn in the opposite direction.

Simple Method of Handling Bulk Cement for Road Job

Very simple methods requiring no special equipment, were used by the Keystone State Construction Co., in handling bulk cement for a concrete road job at Townsend, Del. The plan was described by Mr. Arthur Loeb, vice president of the construction company, in the December Contractors Atlas.

The cement storage house is 150 ft. long by 20 ft., with a capacity of 20 cars or over, 4,000 bbls. of cement. It is very substantially built in order to prevent the possibility of moisture or dampness entering. It has a concrete foundation and a concrete floor at ground level. As shown in the drawing, the railroad siding is located along one side and the narrow gage industrial track at the other.

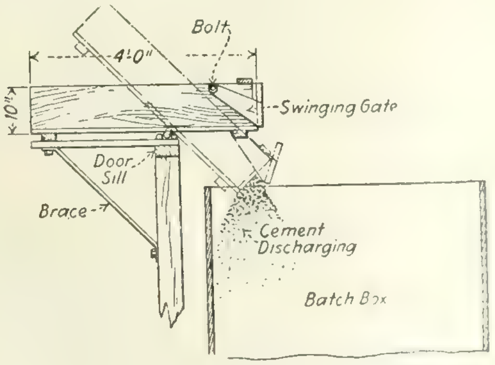


Plan of Plant Layout.

The doors on the railroad side are so located that the cement can be discharged through a chute from the car directly into the house. The upper end of the wooden chute is flared with a cloth nailed over the top to prevent excessive dusting; and is located about breast high so that the cement can be easily shoveled into it.

When unloading the car, two men are used—shovelling the cement in the center of the car directly into the chute. As soon as the unloading progresses to a point where it is inconvenient to shovel into the chute, it is removed and the cement at the ends of the car wheeled into the house in wheel-barrows. Horizontal stringers nailed to the studs and center posts at door level support the wheeling runway which can be shifted at will. When the house is filled to capacity the cement lies level with the door sills at each side of the house.

The cement upon being discharged from the chute is remarkably "lively" and flows to the far side of the building almost like water. For measuring the cement into the batch boxes, a very simple method was devised and it has worked out well.



Detail of Cement Measuring Box.

The doors of the cement house are so located as to be at the proper spacing for the batch boxes on industrial cars. The sills of the doors are located 7 ft. above track level and on each sill there are two tilting boxes, each of the right size to hold 4 cu. ft. of cement—the proper amount for the 4-bag batch used.

The tilting measuring boxes are filled by means of hand-pails—an easy operation because the loose cement can be easily scooped up by the pail. As the level of cement becomes too low for one man to fill the box conveniently, an additional man is stationed below to fill and hand up the pail to the man above. The boxes are all filled and ready for the train of industrial cars when it arrives and is spotted in the proper position. A slight pull tilts the box and discharges its contents through the automatic lift gate located at the outer end of the box.

It would have been desirable to have placed the industrial tracks in a depression below ground. The high ground water level prevented doing this conveniently. If the tracks had been lowered, the tilting boxes also could have been located lower, thus eliminating the necessity for passing up the cement. The tilting boxes should preferably be located at about the height of a man's waist.

Snow Removal System of Akron, O.

Last November, Akron, O., was visited with an unprecedented snow storm for that season of the year, 7 in. of wet and heavy snow falling within a few hours. As a result the Director of Public Service, and the Superintendent of the Bureau of Public Works, were obliged to work out a tentative plan without delay. They watched its operation in actual practice on the street during the period of removal, and as a result of its success, laid down a permanent plan which is outlined as follows in the January issue of The Street Cleaner.

Four instruments are used in handling the snow: (1) Plows; (2) Hand gangs; (3) Scrapers—fresno or snow; (4) Trucks.

Each is under the absolute direction of some responsible member of the department, the first being under direct control of the Superintendent of Streets. Scrapers have two men to direct.

Snow removal is to be conducted so as to make certain specified thoroughfares passable, including the opening of crosswalks, car stops, catch basins, and bridges, without an attempt at useless refinement.

Snow falls are classified as "Light" (less than 4 in.) and "Heavy" (4 in. and more). Under all conditions snow removal is to commence when snow is 1 in. deep.

Light snows are to be handled by plows during the night; and by plows and hand gangs during the day. When snow is falling to reach 1 in. in depth, one scraper superintendent must report at municipal garage to assist in organizing the plows and to remain there to be ready to call out the scrapers if the fall becomes heavy. When morning comes, the hand gangs superintendent reports at garage to direct these gangs to supplement the work of the plows.

If the fall occurs in the daytime, both hand gangs and plows begin operations at once.

In the case of heavy snows, night work, from 8 p. m. to 7 a. m., is undertaken by plows and scrapers; day work, from 7 a. m. to 6 p. m., by plows, scrapers, hand gangs, and trucks.

To avoid delay and facilitate the work, certain general "aids" have been laid down: (1) Each superintendent is responsible for notification and instruction of his crew; (2) Arrangement has been made for the police to turn out men as needed; (3) Superintendents are obliged to turn in reports of time and progress, regularly during the removal work; (4) Responsibility for maintenance of the apparatus during the emergency is placed on one man who is given authority during the emergency, to purchase necessary parts as needed; (5) An officer is given the responsibility of keeping in touch with the movements of each crew and to provide it with such men as are needed, a city car being placed at his disposal for the duty; (6) No variations from the program are permitted except as authorized by the superintendent of streets.

The program includes the lay-out of the entire city, the most important thoroughfare being given first consideration, and so on. This lay-out not only thus maps the city generally but maps it for the four different instruments mentioned above, not all four instruments being applied to all thoroughfares. Furthermore, in mapping the city, the directions which apply to each thoroughfare are laid down so that each street is treated in the manner to best handle the conditions found there. In one it may be a case of pushing the snow to the curb; in another, of plowing snow to piles; and so on.

The rules provide that no step in the program shall be undertaken until all preceding work has been finished.

Relative Service Value of Different Types of Rural Pavements*

By A. R. HIRST,
State Highway Engineer of Wisconsin.

If in a discussion of the relative service value of different types of rural pavements, any one expects specific rules and well-buttressed conclusions, he is doomed to disappointment. It is my opinion that nothing of the kind is justified from the information now available. The term "relative service value" is, itself, open to various interpretations. It might be held to cover only the potential power of a pavement to bear traffic of various amounts regardless of cost or economics, or it might be held to include the two latter factors. The author prefers to include the latter, and hopes that the program committee and the members will excuse the possible overlapping due to this interpretation.

Among the characteristics usually listed as important in determining the service value of pavements, are: (1) Freedom from dust; (2) appearance; (3) character of foothold; (4) ability to clean; (5) freedom from sanitary objection; (6) character as regards noise; (7) freedom from slipperiness, and (8) low tractive resistance.

Almost without exception the characteristics cited above are among the least important of the matters to be considered in determining the service value of rural pavements. Some, or all of these factors, are worthy of consideration in specific cases, but it has been our experience that one, or all of them combined, has had no important bearing upon 10 per cent of the decisions reached in actual practice. They have a much larger value in city and village paving than in rural highway construction.

The predominant factor in determining the relative service value of pavements is whether they serve the traffic effectively and cheaply. It may be given as a truism that given effective construction and proper width, almost any one of a dozen different pavements will give good service. The question to be determined by the highway engineer is whether they have given, or will give, good service cheaply.

Traffic: the First Factor in Pavement Economics.—Highway traffic is, of course, the first factor to be seriously considered in connection with pavement economics. Traffic is the thing which makes highway surfacings worth while, and the thing which wears them out. Its amount and its characteristics are important and should always be taken into account.

We are going to shock a good many of our more theoretical brethren by saying that a preliminary traffic census is absolutely valueless in helping to determine the type of surfacing to be used. An inspection of the location of a road on the map, a knowledge of its relation to other roads and to the general highway system, and to business centers; together with a consideration of the business tributary to it and probably to be tributary to it, will tell a highway engineer, who knows his business, whether the construction in question should be first, second, or third class. The traffic on a road last year or last month has absolutely no value in this connection, because when a highway becomes a part of a superior highway system, or when one highway is paved with a surface superior to that on the adjacent and competing highways, traffic is so concentrated on that highway that what has been is no indication of what will be.

Any assumption of what traffic will be is merely an assumption and the presence on a certain past day of 100 automobiles, 10 trucks, 8 farmers or their wives in single buggies, and 3 babies in their perambulators, has really no bearing on the future situation.

Traffic counts have value only as serving to give accurate information as to the constantly occurring changes in traffic conditions, and in determining the relative cost of service per unit given by various pavements. The unit cost per ton of carrying traffic is the important consideration and, unfortunately, we have little or no information on this point.

The fact that this type of pavement was maintained for so much per annum and that type for so much per annum means little, unless we know the amount and weight of the traffic served and that it was served adequately. Even then the information would not be conclusive, because the pavement which gave this unit cost under the prevailing soil and climatic conditions might give an entirely different unit cost under different soil and climatic conditions. We have been too prone to assume from the results of experience with a limited number of stretches of a certain type of pavement, built and maintained under certain conditions, that the same results will ensue from the use of the same pavement wherever it may be built. This is not the case. Climatic, soil and rainfall conditions must be considered as well as traffic and general performance.

Weight of Traffic and Pavement Service.—Among the important circumstances affecting the service of pavements is the weight of the traffic which the pavement bears.

American highway engineers have been condemned by the unthinking for having built roads which have not stood up under the intense motor traffic of recent years. It would be just as sensible to condemn a railroad engineering department for the failure of railroad bridges under engines weighing 200 tons, when the bridges were designed for engines weighing 20 tons. Before new and heavier loads are allowed on any length of railroad all parts of the construction are examined and, if necessary, strengthened or rebuilt before the new traffic is allowed to pass over them. There has been nothing of this in highway practice. Loads almost without limit have been placed upon highways designed for conditions existing and anticipated a decade ago, and condemnation has resulted when the inevitable failure of the road structure ensued.

It would seem that it would be clear to even the feeblest-minded that it is not going to be possible for the designers of vehicles using highways to turn loose upon highways any behemoth their ingenuity may design at any time they feel like doing so. It isn't possible to reconstruct the highway system of America every few months, or even every few years.

It is imperative that the various states adopt uniform standards for the loads to be borne by roads of the different classes of importance. It is going to be difficult to do this, because when a motor vehicle is once started toward its destination its operator will wish it to carry its full load for the whole trip, but it seems inevitable that we must classify highways as to the allowable loads upon them, and that traffic on highways must be made to conform to these loads. All roads cannot be made 15-ton roads every day in the year.

It is undoubtedly going to be possible for the states to finance ultimately the construction of roads between their congested centers and certain through highways which will every day in the year permit loads of 12 to 15 tons or, if the economics of transportation really justify it, even more. But just as certainly it is going to be impossible for the states to finance the construction of any great percentage of their roads so that they will stand such loads every day in the year, and I believe that on the secondary roads and roads of the lower classes, much lower load limits must be insisted upon, especially at certain seasons. The importance of this matter upon the design of pavements and upon the service of the several types cannot be over estimated.

Continuous Travelability Important Factor.—One of the intangible factors in the service value of types of pavement is the factor of continuous travelability. It goes without saying that given two pavements of equal annual cost, one of which is out of service for several days each year and probably for two or three months at several times during the assumed pavement life, the other one allowing the passage of traffic during its life with practically no inconvenience and no detouring, the choice would immediately fall upon the one which gives the superior travelability. Furthermore, if the maintenance of one type demands annually, semi-annually or periodically, the application of such materials that traffic cannot be accommodated during the application or, if accommodated, is subject to possibility of accident from slipperiness and to defacement of vehicles and clothes, it is a serious impairment of the service value of the pavement.

One of the strikingly characteristic things about American highway practice has been the almost total disregard for the comfort, convenience, and economy of the traveling public during construction, maintenance and reconstruction. A public-be-damned policy has been quite generally practiced. The traveling public has been considered as an interloper, with no possible business save to pay the bills. He has been stopped from passing through main roads without any option of detours being offered him. He has been not stopped by barriers and has been encouraged to go upon construction and maintenance work which has impaired and [illegible] tires, his vehicle, his clothes, and his religion, to the extent of hundreds of thousands, and, possibly, millions of dollars. Even where detoured, he has been only in very few cases properly guided along the whole length of the detour, and even where the detour has been marked, almost without exception it has not been maintained. Even at the best, given a closed road, a well marked and well maintained detour the economic loss to the traveling public has been tremendous. For example: A road carrying a traffic of 1,000 vehicles a day is closed for a length of five miles due to construction or reconstruction, for a period of four months, the detour being eight miles in length, a loss to traffic of three miles. The total traffic loss is therefore 360,000 miles, which, at 12c a mile, is $43,200, a figure which may well have a material bearing upon the type of pavement which one should select. Similarly derived figures will illustrate the importance of speed in construction and reconstruction and demonstrates that it is usually worth paying for.

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*[illegible] annual meeting of the American Association of State Highway Officials, Washington, D. C., Dec. 13-16, 1920.

Factors Entering Into Economic Comparison.—We have been too prone to select types of pavement on the say-so of others without very material consideration of the matter of cost. The minute we commence to discuss the relative cost of pavements we are thrown into the ocean of economic discussion at a point far beyond our depths. We are immediately brought in contact with the question: "Should an engineer in weighing the merits of two or more types of pavement consider the factor of interest on the original investment?" Many good authorities say "Yes"; many good authorities say "No." I do not pretend to be good authority, but I am sure that the answer is "Yes." The statement that the value of the pavement in increased comfort, convenience, saving in hauling, saving in gasoline, tires, etc., far offsets the interest on the investment, sounds very nice; but what is one going to do about it when one is considering two types of pavement, both of which do all of these things, but the costs of which are very dissimilar?

In addition to this difficulty with the basic economics of the situation, we have the further trouble that in comparing the unit annual cost of various pavements, we must make assumptions as to the lives of pavements, and we have little or no information on which to base these assumptions.

It might be of some value to cite the factors entering into an economic comparison and to show just how far one can get in his figuring:

1. First cost of the pavement.—This is readily determinable within the limits of estimating and causes no trouble.
2. The interest charge on the pavement investment.—This charge should be compounded annually and is, of course, readily determinable.
3. The annual cost of maintenance of the pavement.—This is only moderately guessable because no one can tell what the cost of the materials and labor entering into repairs will be next year or in succeeding years. Furthermore, no one can guess what unexpected development of traffic may entirely upset the conditions under which the surface exists.
4. Interest on the maintenance cost.—This should be added to the cost of the pavement and should be compounded annually.
5. The assumption of the life of the pavement before total reconstruction is necessary.—Again we are in the field of theory, because the life of the pavement depends upon the traffic which it will carry through a series of years, which we can only guess at. Furthermore, on many of the pavements which are now being widely used, enough information is not available to determine what the life may be, and even on some of the older types of pavement, built under supposed to be standard and fool-proof specifications, a variation in life of several hundred per cent has been noted.

The summation of items 1, 2, 3 and 4, divided by the number of years of expected life of the pavement gives the annual cost to the public of the pavement so far as the mere outlay of money is concerned.

Before the division by the number of years of expected life is made, however, there should be subtracted from the total cost the value of the old pavement for use in the new pavement. Here again we are in the realms of guesswork. Assuming that a certain type of pavement can be preserved for 20 years and will then need resurfacing or replacement by another type, we are making a grave assumption if we value the base at anything very material, because the change in traffic on rural highways is so rapid that it is very hard for one to say that the alignment, grade, culverts or structures that we are building today, or the widths that we are using, will be of any great value to our successor 20 years from now.

On less important roads it is probable that structures being built today will have a very good value as a part of the structures which will replace them. But on roads of the first class there is grave doubt as to whether or not any of the surfacing will be of value to the kind of pavement that will be placed 20 years from now. A guess can, however, be made, considering all the factors surrounding the situation, and, as stated above, the sum so determined should be subtracted from the total cost in order to arrive at the annual cost.

At the end of this series of guesses and assumptions upon assumptions, one will have some basis, better than no basis, for comparing the annual cost of the types under consideration.

Too Narrow Widths Multiply Maintenance Troubles.—We highway engineers have been designing pavements of too narrow widths, and have multiplied the troubles of maintenance by confining traffic to one or two very restricted lines. The conduct of all pavements, especially of the so-called inferior pavements, such as waterbound macadams, gravels, and the lesser non-rigid types, is good or bad in almost direct proportion to whether they have been built wide or narrow.

We have had a very large amount of discussion of the importance of drainage on highways, and I am not minimizing the importance of drainage when I state that I am convinced that many of the faults of the lesser types of surfacing, of which we are complaining, are due to the fact that we have concentrated traffic upon too small units of area, and that a better distribution of traffic will do away with much of the trouble with these types, probably a larger share than will super-refinement in the treatment of the drainage.

I believe that the superiority under traffic of the macadam highways in England and France has been due in part to superior construction, in part to the age of these highways, in part to lesser traffic, in part to the climate, but more largely to the greater widths used in these countries and the consequent better distribution of traffic.

I am not going to develop this thought in detail, but I believe that highway engineers will find that, if they will design the so-called non-rigid roads wider and flatter much of the trouble incident to the present use of these structures will be avoided.

A supposed-to-be two-track concrete or other rigid surface road built 14, 15 or even 16 ft. wide on a main-traveled highway has its service value greatly reduced by its inadequate width because it breeds disastrous accidents and causes worry at all times. The shoulder maintenance is also a constant source of worry and grave expense if traffic is at all heavy. Furthermore, the concentration of traffic and the crowding to the extreme edge reduces the effective life of the pavement very materially.

It is our opinion that even the rigid types of pavement must provide for a moderate distribution of traffic if they are to hold. The minimum two-track highway is 18 ft., and 20 ft. is better on principal highways. If municipalities cannot finance these widths they had better build part of their lengths of a cheaper type, pending the securing of more money.

Plastic or viscous surfaces of all kinds must have width to allow for traffic distribution, especially if built in a climate of wide total temperature variation. On these types especially traffic must be distributed so that it will heal its own marks and not deepen them in heated periods.

On primary highways, unless convenient detours are available, all pavements which from their nature require frequent surface attention embarrassing to traffic should be constructed wide enough so that they can be maintained and repaired one-half at a time.

Design and Service Value.—The service value of any kind of pavement depends largely upon proper design. It is not only necessary that the pavement be well drained, that it be built of the right depth and width, but the materials in it must be properly sized and prepared. For instance: A gravel road built of uncrushed and unscreened gravel, varying in size from sand to cobble stones as large as one's head, has practically no service value today, because it is impossible to maintain such a road so as to give satisfactory service. On the other hand, a road built of the same width and depth and of the same gravel properly crushed and filled may give most economical service. We in Wisconsin have reached the point where we don't want any gravel within 4 in. of the surface larger than 1 in. and we prefer to have no gravel in the whole structure larger than 1 in. The smaller the gravel the better, our experience indicates.

The service value of any highway may be seriously impaired by the use of sharp and dangerous curves, poor alignment, narrow bridges and culverts, heavy grades, and unnecessary lengths. A well laid out highway of inferior surface will many times give better service value than a poorly located highway built with the best surface. Expressed in terms of real service value, type means little unless the selection of a proper type is supplemented by proper design and proper layout.

We believe that maintenance is the keystone of the entire structure of pavement service. Proper selection, design, layout and construction must be immediately followed by intense maintenance if the potential service value of a pavement is to be secured. Any discussion of the service value of any type of pavement has no basis unless the assumption is made that good maintenance protects the pavement and gives it a chance to serve. Types seemingly unsuited for the traffic may, when properly maintained, give better service than a much more suitable surface left to care for itself.

Traffic Distribution and Maintenance Costs.—I am going to interject just a word or two on the important topic of traffic distribution. We are prone to view future traffic development entirely upon the assumption that one road between two points is going to serve all traffic between these points for all time. I doubt that this is true. Alternate routes will be developed and traffic thus distributed. This will be good from many standpoints. It will prevent traffic congestion, allow the use of cheaper surfacings, accommodate more local traffic, provide a choice of routes, and allow for repairs and reconstruction without closing all available routes. The road problem of America is not to build a few boulevards; it is to build, maintain, and keep always open, a transportation system.

Wisconsin has now maintained her 5,000-mile state trunk highway system for three years, and over 2,000 additional miles for one year, and we have gained some idea of the maintenance cost of various types. The condition of the several sections varied so much when they were taken over, and the relative service given is so dissimilar that very little can be determined from an inspection of our figures on maintenance costs.

In 1919 the average cost of maintenance per mile of all types, surfaced and unsurfaced, was $254. The average cost of maintenance per mile by types (taken from a large number of sections) was as follows: Earth, $223; gravel, $212; waterbound macadam, $516; penetration macadam, $252; concrete, $337. Qualifying these figures, it would be only fair to say that the earthroad maintenance included much heavy blade grader reconstruction; that the waterbound macadams had been allowed to get badly out of repair; and that all but $62 of the $337 for concrete was used in shoulder and ditch maintenance and in applying gravel to shoulders on the too narrow 16-ft. surfaces.

As indicating the possible value of well maintained gravel roads we segregated nine very satisfactory patrol sections of gravel road and tabulated at least two separate traffic counts on each. The average count on these roads was 1,059 automobiles, 44 trucks, 21 motorcycles and 48 horse-drawn vehicles per day. Weight was not taken. No effort was made to get maximum day counts. The roads in question gave excellent service every day in the year. The average cost per mile per section of maintaining these nine patrol sections was $263. These roads were not surface treated.

The above figures may be of some interest, although we have ourselves not been able to draw more than broad inferences as to possible service limits and costs from them and other similar compilations.

Our experience with gravel roads indicates that when well built of adequate widths with fine crushed materials and well maintained their traffic limit is far higher than has been [illegible]

Factors to Be Considered in Determining Economical Type.—In considering the relative service value of pavements one cannot [illegible]. There are, when considering a road problem and when determining an economical type to be used, always these factors to be considered: (1) The expected traffic; (2) the materials locally available; (3) the funds available; (4) the whole financial, traffic and highway situation in the unit of government to be served. This last factor is far the most important one, and too often has been totally disregarded.

We have thought too little about the basic function of highways which is of course to offer facilities for travel. We have been too prone to concentrate upon a specific length of highway and economic design, rather than to concern ourselves with the more important traffic situation in the unit of government in which we operate. We have been content to design and build a few miles of highway each year and to look forward with the hope that some day the contemplated system would be completed and traffic would be free to come and go as it pleased. We have closed our eyes to the fact that in the meantime we had on our hands scores or hundreds of thousands of miles of highways which are difficult of travel at all times and impassable at some.

The highway authorities of each unit of government have before them a traffic problem. That is, they have a certain mileage of highways in a certain condition which now bear a certain amount of traffic, and the legitimate development of this traffic can be partly foreseen. They have available or they believe that there can be made available in a definite period, which they can select, a certain sum of money. Of course, the sum of money which may be made avilable is contingent upon certain circumstances usually beyond the control of the authorities. However, they can analyze their traffic problem, and their highways, and can assume the sum which they must have, and which they believe they can get within a definite period of years, and can then determine about what should be done with this money, so as to give their clients, the public in that unit of government, the best result in traffic service during the designated period.

I don't know whether I make myself clear or not, but the point I am trying to drive home is this:

Far more important than the mere selection of a truly economical type of construction for assumed conditions on a specific highway is the importance of determining what program of improvement will be of the most benefit to the traffic in a designated area.

Economics of Pavement Design.—The schoolman has so obsessed us with his ideas of so-called true economics in pavement construction that we have been inclined to lose sight of the much more important economics of the traffic situation as it exists and as it may be expected to develop. We have been so impressed with the importance of economic design of specific stretches that many of us have entirely lost sight of economic design for a traffic situation. If unlimited funds, labor and materials were always available it might be possible that the schoolman is right, and that we should never build anything but the truly economical surface, but there is always a limit to the funds which can be made available, or which can be expended in a specific term of years. The true economics of pavement design is to find the solution which gives the least cost, not only of the construction and maintenance of the pavement, but in the carrying of traffic in the designated area within the designated period.

I may be able to make my idea clearer by giving a short illustration: Normal County has 200 miles of road of the most importance, 200 miles of secondary highways, important from the county standpoint, and 400 miles of strictly local highways, cared for by the local units of government. Outside of the funds which can be made available for the general maintenance of these 800 miles, it can be foreseen that in the next five years the total funds available for highway improvement in Normal County will be $4,000,000. Of the 200 miles of first class highway, 50 miles have been surfaced in the past and are still maintainable, and 150 miles are earth, without hope of redemption. Of the 200 miles of less importance, 20 miles have been surfaced and 180 miles are earth. Of the 400 miles of local roads, all are earth. Traffic conditions are at present intolerable in the county. Each rain means a blockade; each spring and rainy season an absolute cessation of traffic except by team, and that traffic is almost blocked.

The $4,000,000 available in the five years will, it is estimated, build 100 miles of the schoolman's economically correct highway. If the public officials determine to build this type of highway, at the end of five years there will be 230 miles of the first and second class highways (o [illegible] cent of the whole) still unsurfaced. Isn't it plain that this answer cannot be correct, regardless of the so-called economics of the specific instance? Isn't it plain that the public body controlling the money should consider most carefully the whole situation, and spend the $4,000,000 in an effort to make passable at least all of the 400 miles of principal highways?

The schoolman will say that some of the money is wasted because a portion of the types built are not going to exist for 20 or 50 years, but the economic waste incident to the use of uneconomic types is not a marker to the economic waste incident to the continued use of a largely unimproved system of highways. In other words, the loss to traffic by the prolongation of such a situation is usually infinitely more than the loss to the public due to the construction and maintenance of types requiring renewal after a term of years. Carried to a logical conclusion, some one will say, this plan means building largely temporary surfacings, and later on building again. It does! And why not, if that is the true economic solution? Most of our railroads have been rebuilt more than once. I believe we must proceed along exactly similar lines. First accommodate traffic, building to the money which can be made available, expecting that after the traffic is gotten through and the adjacent territory reaches fuller development, the necessary betterments will follow.

Federal Aid Construction in Wisconsin.—There has been considerable criticism to the effect that a large proportion of the Federal aid construction is going into low-class structures and that therefore the funds are being wasted. Ninety per cent of these critics never designed or built a highway, nor have they ever tackled a legislative body to get it to finance one.

In Wisconsin about 19 per cent of our total mileage of Federal aid construction will be concrete, 2 per cent macadam, 42 per cent gravel, and 37 per cent earth, with modifying surfacings to make them passable. Expressed in terms of money, about 40 per cent will go into concrete, the remainder into grading and other types. Every project solved a traffic problem and freed a community from impassability or danger. No one can tell me nor can he tell the communities in which the work was done, that the money was wasted. Our critics, themselves, if faced with the same problems, would have come to the same decisons.

We hope that all states will hold to safe ground and serve traffic now. Deviation from this policy is more apt to waste money than is adherence to it. Probably more federal and state money has been wasted in prematurely building unnecessarily expensive types of surfacing than has been wasted in grading and building the lesser surfacings. After all, the one thing that is permanent about road work—the one thing that cannot be done too well or too soon, is proper grading on correct locations. Those states that are feeling their way by doing much of this kind of work at places where traffic has been previously stalled by grades or drainage conditions are not wasting money—they are investing it with profit.

Common Sense and Business Judgment and Relative Values.—It may be inferred from this paper that it would take the brain of a Demosthenes, the genius of an Edison, and the engineering skill of a demigod to determine what pavements should be built, given a condition, these theories, and a sum of money. Such is not the case. In four cases out of five a decision can be readily and quickly made when all pertinent facts and circumstances are known. It takes, largely, common sense and business judgment sufficient to grasp relative values. It is a matter of experience and judgment, rather than of the slide rule and arithmetic.

We have used too much higher mathematics and too little common sense. We have sought to set ourselves upon a pedestal of economic perfection and have closed our eyes to many of the surrounding circumstances, until many of us cannot recognize a real economic fact when we meet it. The people are commencing to demand results rather than higher economics. They don't know much about pavement economics or relative economy of types, but they do know when and where they were stuck in the mud and where they broke that last spring.

There are too many hundreds of millions of dollars invested in means of motor transportation, and too much pleasure, comfort, convenience, economy and time saving depends upon their immediate, economical and safe use for us to trifle with the facts as they exist. The owners of these vehicles demand service. They must be given it. This despite the fact that many manufacturers of motor vehicles persist in pursuing the ignis fatuus of highly centralized highway systems and of highly concentrated construction. Automobiles and motor trucks are owned on almost every square mile of territory and use every main highway. They cannot serve or attain complete efficiency unless they can get through everywhere—now! Why their producers should deliberately work to limit their use offers to me an enigma impossible of solution.

It would be nice indeed if we could serve traffic always and immediately with the ultimate, but it is mechanically impossible. Until we can so serve it we must meet the situation which exists and get the best result we can with the means at hand.

Let's not worry so much about our predecessors or our successors; let's do our best for our contemporaries. Service value desn't necessarily mean the ideal for the next decade, it may better mean service value right now.

A county or state highway department should not exist merely to design and build a few miles of highways and a few culverts and bridges. It should exist to give transportation service to its clients. We should be purveyors of transportation to the American people. Traffic must be served.

Conclusions.—Summing up very briefly the meat there may be in this article we can say as follows:

1. Service value must always be considered with reference to service cost.
2. In comparing the relative service value of pavements, interest on the successive investments should be included in the gross cost.
3. Soil, climatic and rainfall conditions have a bearing on service value and should be always reckoned with.
4. Width is an important factor in service and has a very large bearing on the conduct and maintenance cost of pavements, especially of the inferior types.
5. Proper design and layouts are important, regardless of type, and poor design and layouts seriously impair the service value of the best types.
6. Traffic has a grave bearing on service and must be restricted and controlled in advance of construction plans.
7. States must probably divide their roads into classes and name the limiting load for each class. All roads cannot be made 15-ton roads every day in the year.
8. It is not always possible to build the surface that will give the most economical service on the specific portion of highway, and it is not always advisable to do so.
9. There can be no comparison of service values without assuming proper maintenance of all types of surface.
10. Constant travelability is supremely important, especially on main traveled highways, and will often determine the type and width of surface to be used.
11. In planning improvements consideration of the traffic problem is of the gravest importance. Before any extensive program is laid out, the executives who control the construction should carefully survey the traffic situation and the highway conditions in their own and the surrounding units of government and plan to meet them.
12. We should probably seek to decentralize and spread intense traffic on several roads rather than seek to put it all on one.
13. Expediency is not always wicked; it may sometimes be another name for common sense.
14. It is better to travel over an uneconomically designed but passable highway system than not to be able to get through on a theoretically perfect one.
15. The function of highways and of highway departments is to serve traffic and to furnish means of transportation.
16. Today's traffic must be served.

Court Ruling Favors Illinois Road Bond Issue.—The Circuit Judge at Carbondale, Ill., on Jan. 29 decided against the plaintiffs in a case in which proceedings were brought in that county to enjoin the governor from construction of state bond issue hard roads. The plaintiffs were dissatisfied with the route chosen by the state highway department. It is stated that had the plaintiff in the communities dissatisfied with the routes selected by the highway department would have instituted similar proceedings, with the probability of delaying indefinitely the $60,000,000 state hard road program.

A New Self-Computing Level Rod

By E. P. EFFERTZ,
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The self-computing level rod has been used for years. Patents have been issued on several different types, some of which have expired. Engineering and Contracting has at different times described the details of construction and the method of operation of one particular type which is being manufactured and is in quite general use at the present time.

The writer has designed and constructed a self-computing rod of the movable continuous ribbon type which to the best of his knowledge posesses features original with him; and which he has found an efficient aid in cross-sectioning work on highway surveys and construction. The rod can also be used as a self-computer in other leveling operations, or if desired, as a rod of the ordinary type; but its greatest advantage is in the taking of cross-sections.

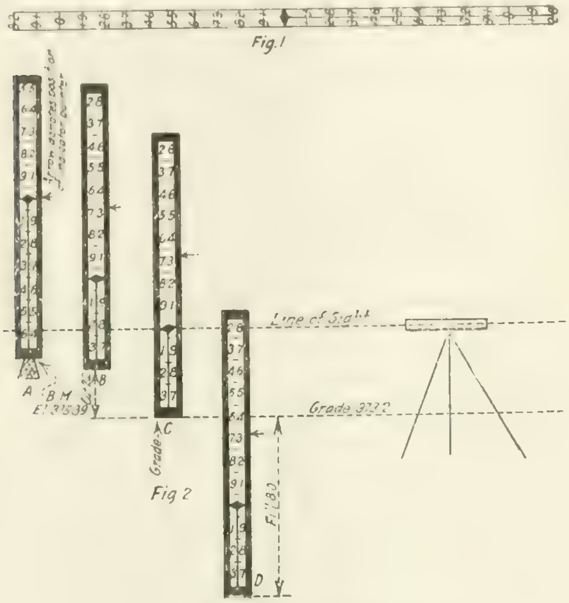

Fig. 1

Fig 2

Figs. 1 and 2—Self-Computing Level Rod.

Following is a description of this rod and the method of its operation. Figure 1 shows graduations on the movable continuous ribbon. The length of the ribbon is twice the length of the working face of rod. The ribbon shown is 24 ft. long and is used on a rod that has a 12-ft. working face. Only the foot marks are shown in the sketches. The actual scales are divided into feet, tenths and hundredths. There are two scales side by side on the ribbon, the one on the left running progressively downward and the one on the right running progressively upward. The zero points are directly opposite each other. The middle zero or zeroes is marked by a diamond-shaped figure to distinguish it from the zeroes near the end. When placed on the rod the two ends of the ribbon are joined so as to make it continuous. In operating the rod, the middle zero or diamond must always remain on face of rod.

Owing to the limited angle of vision of a level, it is impossible to see the entire length of the working face of rod when it is close to the instrument. As shown later, it is very necessary that the instrument man know whether the diamond is above or below the line of sight, and to distinguish the lower half of ribbon from the upper half, a heavy line is drawn, beginning at the diamond, and running down the middle of the ribbon between the two scales. This marking will enable the instrument man to determine instantly the location of the diamond with reference to line of sight.

On the right side of the rod there is an indicator pointer which can be set and clamped at any desired point along the working face.

Figure 2 illustrates the manner in which the rod is used in setting slope stakes and cross-sectioning when elevations of cross-sections are referred to grade. The elevation of B.M. is 375.39 and elevation of grade is 373.2. The rod is held on B.M. shown at "A" Fig. 2 and the ribbon is moved so that the reading on the scale on left corresponds with the elevation of the B.M. The indicator pointer is then moved to the diamond and clamped. Then to set the rod for the grade 373.2, the ribbon is moved down until 3.2 on the scale on right is even with the indicator pointer, and clamped. The cut or fill of any point on the cross-section can then be read directly. The cuts are read on the left scale and the fills on the right scale. At "B" there is a cut of 2.2, at "C" "grade" and at "D" a fill of 8.0.

With the instrument in this first position and the indicator pointer being clamped, the rod can be set for different grades by moving the ribbon up or down until the reading on right-hand scale opposite the indicator pointer corresponds with the required grade. In this operation the diamond must be kept on the face of the rod. Referring to A, Fig. 1, it is seen that the diamond can be moved down 6.7 ft. or up 5.2 ft. without disappearing from face of rod. When the diamond is at the bottom of the working face, the indicator pointer will read 6.7 and the rod will be set for a grade of 376.7; and when the diamond is at the top, the indicator pointer will read 4.7, and the rod will be set for a grade of 364.7. Thus it may appear that the rod can only be used for grades within a 12-ft. limit, which in this case is between 364.7 and 376.7. But this is not the case. Suppose, for example, that the grade required is 383.2. Set the rod for a 373.2 grade as in Fig. 2. The diamond then will correspond to a fill of 10.0, it being a fill of 10 ft. from 373.2 to 383.2. Then in Fig. 2 there would be a fill of 10.0 at C, a fill of 7.8 at B, and a fill of 18.0 at D. In this way the rod can be used for any grade outside the apparent 12 ft. limit. The diamond will correspond to a fill of 10.0 or some multiple of 10, or a cut of 10.0 or a multiple of 10.

After doing all the "slope-staking" or cross-sectioning that can be conveniently done from the first set up, a T.P. is taken. To get the elevation of T.P., the diamond is moved to the indicator pointer and the elevation of T.P. is read directly. The instrument is then moved ahead and the work is continued from the T.P. as from the B.M. at the first set-up.

In hilly or brushy country it is often impractical to take cross-sections or set slope stakes with a large level. In such places the work can usually be done to more advantage with a hand level.

To set slope stakes or to take cross-sections when elevations on cross-sections are referred to grade, when using a hand level, the rod is held at the station stake and the ribbon is moved until the reading at the observer's line of sight corresponds with the center cut or fill. The ribbon is then clamped and the rod is taken out on the cross-section and the cuts or fills read directly on either the right or left scale as the case might be. Should it become necessary to take a turn it is done in the following manner: Suppose the rodman is going out on the down-hill side. He selects a T.P. and the observer reads near the top of the rod, say, a fill of 3.2. The observer then moves down the hill so that his line of sight hits near the bottom of the rod. With the rod on the T.P., the ribbon is moved until the observer reads a fill of 3.2 on the right-hand scale. The ribbon is then clamped and the work continued down hill. Turning up hill is performed in the same manner.

In cross-sectioining with a hand level, the elevations of cross-sections are sometimes referred to the ground elevation at center line. The work is carried on in the same manner as just explained, except in starting at center the observer reads on the diamond.

Features of California Road Building Program.—The California State Highway Commission in its report submitted last month to tthe State Legislature outlines certain fundamental features of the road building program. These include first. routing, so far as practicable, over the shortest routes between termini; seconw, cement concrete as a standard construction base, and, third, the unit plan of construction. A heavier duty road now being required than was the case when construction started ten years ago, the commission says, it has increased the depth of base from 4 to 5 in. of reinforced concrete. A minimum width of 20 ft. is not held advisable because of the greatly increased cost per mile, and it is held best to continue the 15-ft. minimum, with widths varying up to 20 ft. as traffic conditions seem to require. Old road betterment, it is stated, is also being given careful consideration and a fair proportion of funds.

Preparation of Estimates for Highway Work

In view of the rapidly changing economic conditions in the past and the uncertainty as to the future, estimates have been giving and are going to give highway engineers considerable trouble. An interesting discussion of this question of estimating, from the standpoint of a state department, was given by Mr. H. J. Kuelling, Construction Engineer of the Wisconsin Highway Commission, in a paper presented at the annual convention of the American Association of State Highway Officials, held at Washington, D. C., Dec. 13-16, 1920. In his paper, an abstract of which follows, he describes the plan that has been tried out in Wisconsin during the past year

Local Conditions Must Be Analyzed.—It is assumed that the economical type to be constructed has been previously selected. This statement is made because of the fact that in making estimates, factors are very often uncovered which warrant a change in type

Before any figures are made on an estimate, the engineer must carefully analyze all conditions surrounding the work. He must spend time in seeking out all local information relative to every feature of the work. This local information may pertain to availability of materials; freight rates; railroad accommodations, as to sidings and train service; camp sites; water supply for these camps; availability of supplies for these camps, whether they come from merchants or farmers; the soil conditions, whether or not they are conducive to a small weather loss; whether the sand is so soft that it will interfere with the movement of equipment such as wheelers, or wagons; the kind of clearing and grubbing, whether there are deep rooted trees or flat rooted; the type of marsh conditions, if there are any, whether it is possible to work horses or equipment on them; the kind of grades that may be encountered in the work, which will have a bearing on the hauling of materials, or the pumping of water. In fact, he must seek information on a great variety of subjects.

In seeking knowledge of materials he must know the capabilities of commercial concerns to ship, whether they are in a position to get cars, whether they have the proper capacity to turn out the amount of material they are liable to contract for; whether their material is satisfactory; the business reputation of the concern, whether they will keep their word or not; that is, whether they will ship in accordance with promises or whether they will ship to someone that comes along and offers them a higher price at a later date.

Seeking information on local materials, the engineer must be even more careful, as he must know the kind of materials available, the amount, especially if a gravel deposit, as these are likely to pinch out; he must know the cost and should have an option on it, so that one contractor by getting this option, cannot bar others from bidding.

The mere investigation of present used matarials is not sufficient, as there are many cases where materials are being hauled several miles when there is a sufficiently good supply within a very short distance of the job. Entirely new and unknown sources of supply can be found in any state by a painstaking materials department. The changes of the freight rates, if there are any new increases, should be balanced against the extra distance that local materials can be hauled.

Force Account Work to Secure Cost Data.—After an engineer has obtained or been furnished with all this local data, he is still very much handicapped in making his estimate, unless he has had considerable experience in actual construction. He should know the best methods of carrying on the work, what equipment to use, whether it be a grading or surfacing job. With the amount of work that is being done by every state in the Union, the simplest, most practical and only satisfactory way to get this cost information is for the various states to do some of their work by force account. The writer knows that some states cannot legally do this, but believes that provision should be made so that they may. It will be surprising to many of you to find out the items that crop up and that must be paid for on a construction job. Some things are hard for an engineer to realize unless he has been through the mill.

The state from which the writer comes has taken this stand for years past and has done a very great amount of certain types of work by force account. Up to the time of federal construction, this force account work was entirely in the hands of the county authorities and only under the general supervision of the state. Since the federal construction began, the state has undertaken a number of jobs by day labor and, in fact, in 25 of the 71 counties during the past season, part of the work has been done in this way. This does not mean that the majority or even a large per cent of the work is done by force account, but enough is done so that the state will have first-hand and accurate knowledge of costs. Owing to the variety of work and conditions, it requires several jobs along different lines. For instance, on concrete road construction during the past season, one job was run by day labor where the material was dumped on the subgrade and handled by wheelbarrow. This material was shipped in from commercial plants to a special siding and transferred by a clam to side dump cars on an electric railway which ran along the highway and dumped directly on the subgrade. In another case, a local pit was developed and the material hauled to the road by trucks. It was then mixed and placed, the mixer being loaded with wheelbarrows. In a third case, a local pit was used, the concrete mixed at the pit, hauled in a mixed condition by industrial railway and placed on the subgrade with a large crane.

In grading operations one job was undertaken in a sandy soil; one in gravelly soil; one in clay soil; still another in very stony ground. Some work was done by steam shovels and some by wheelers and fresnos. In a similar manner various kinds of gravel work were undertaken—some with sandy gravel, some with clay gravel, and some with gravel that would hardly be worthy of the name of gravel—in other words, really top soil.

With an accurate cost analysis of all of this work at hand, we feel that we are in much better position to determine whether or not the bids submitted to us are satisfactory.

After progressing this far in the making of an estimate, the writer believes that the states should have a regular system of making these estimates. In fact, he sees no reason why a committee from this organization could not develop a scheme or schemes for having all the states make their estimates in the same manner. This scheme, whatever it may be, should be after the same fashion and, in fact, can well comprise the very same forms that a contractor should use. There is no reason why the drawing up of such estimate forms could not be partly done by the contractors, or in conjunction with them. This scheme of having the contractors work with the engineers has been tried out during the past year in Wisconsin, with more or less success.

Wisconsin Form of Estimates.—A year ago, the Wisconsin State Highway Department called a two-day meeting of contractors, machinery men, material producers and the engineers of the state. A very open discussion was had regarding the relations of all parties concerned. At this meeting a committee was appointed, and instructed to draw up a form for making estimates. This committee was composed of five contractors, elected by the vote of the contractors themselves, one man from the aggregate producers, one man from the machinery manufacturers, three men from the county construction departments, and two from the State Highway Department. This gave a committee of five engineers, five contractors and two others who were vitally interested in the meeting. This committee met for three different sessions and they were sessions at which work was done. The contractors, as a rule, were frank in their statements, and out of it grew an estimate form for one type of construction which seems to be fairly satisfactory to all concerned. No doubt it has many faults as yet, but it is a start in the right direction. This form is drawn up primarily for a concrete road job, but it can be very easily adjusted to other types of surfacing. The committee did not complete an outline for estimating grading work, but it is hoped that it will do so sometime in the near future. It did, however, touch upon certain features of it.

There is perhaps more guessing done in making grading estimates than in any other kind of road work. There is a greater need for some satisfactory method for estimating grading costs than for most kinds of road work. Too often the average haul is not even known. A greater use of the mass diagram would be beneficial.

The attendance of this committee was almost 100 per cent and the meetings were lively, as many discussions arose. All points were finally amicably settled and the form is used quite freely throughout the state. The form as developed is divided into 16 subdivisions as follows:

Cost of siding.
Moving of equipment to the job.
Lost time of moving equipment.
Cement.
Fine aggregate.
Coarse aggregate.
Surfacing.
Camp loss.
Miscellaneous cost.
Contingencies.
Compensation and public liability insurance.
Bond cost.
Overhead.
Profit.
Charges for machinery and equipment.

Each of the above items is subdivided into as many divisions as were considered necessary by the committee. Most of these items you will readily see are somewhat easy to determine, but others are not. Only a few will be discussed here.

The committee finally put overhead on a percentage basis. For instance, in figuring a job the contractor or the engineer would have to estimate the per cent of the manager's time that would be required for the job, and then charge up that per cent of his yearly salary to the job. The same plan is applied to his office force, time keepers, the expense of the manager, his office rent, supplies, etc. Overhead also includes the corporation insurance, interest on the necessary working capital and any dues that may have to be paid to associations.

Upon the item "profit," the committee had a rather heated argument. Naturally, the contractors were anxious to obtain as much profit as possible and have the state officials agree to certain percentages. This, however, we refused to do and the per cent of profit was left blank for the contractor to fill in as he desired. What we were seeking was primarily to get everyone to make their estimates along the same line and then let the contractor be his own judge on whether or not he could get the job with certain profits added on.

In the last item, charges for machinery and equipment, the committee had perhaps the most interesting discussions. Charges for surfacing machinery and equipment were worked out to certain percentages per mile of road constructed. For instance, under concrete pavers, we assume that the paver will build 30 miles of standard 18-ft. road, at the end of which time it will be completely used up. The same result was obtained if we assumed that it would build 24 miles and at the end of that time have a salvage value of 20 per cent of the original cost. With the 30 mile, and an average per year of 6 mile, the life of the mixer would be five years. Depreciation, therefore, in five years equals 100 per cent, repairs in five years at 10 per cent, would equal 50 per cent of the original cost; and interest, storage and insurance would equal 30 per cent of the original cost. This would make a total of 180 per cent of the total cost to be spread over 30 mile, or 6 per cent per mile. In other words, in figuring the charges for machinery, the contractor, if it was a standard 18-ft. road, would merely multiply the number of miles by 6 and take that per cent of the original cost of his paver as the amount to be charged to the particular job under estimation. In a similar manner, the committee arrived at percentages for various types of equipment used in the surfacing work.

The per cent on grading and hauling equipment naturally could not be arranged by miles. It must be worked on a time basis and cannot be as accurately determined as surfacing equipment, because of the greater variation in quantity and kind of excavation on different jobs. Final percentages have not as yet been arrived at by the committee for these types. The committee did state that including depreciation, interest on investment, storage, insurance and all repairs, but not including fuel, the percentage per operating day would vary from ¼ per cent to ½ per cent of the original cost, depending upon the kind of equipment.

There is no doubt that a continued use of this form will bring out points of weakness, but the writer believes it is a step in the right direction and that within a very few years standard forms of estimating will be in use for road work and that there is no reason why these same forms cannot be used both by the contractors and by the engineers.

There is also no doubt that adjustments will have to be made for certain local conditions which are not covered. Where there is something to guide, there is no reason why the contractor and the engineer should not be a little more in harmony than they have been in some cases in the past.

Short cuts in estimating are needed and can be devised by state departments. Care should be taken, however, not to make these too short. No scheme will ever be devised or charts drawn so that a novice can make highway estimates. It is only by the use of brains and knowledge of conditions influencing costs that proper estimates can be made.

Wages and Material Costs 1915-20 on Oregon Highway Construction

The accompanying tabulation from the recently issued biennial report of the Oregon State Highway Commission, covering the period Dec. 1, 1918, to Nov. 30, 1920, shows the average prices on highway construction materials f.o.b. Portland, Ore., and the average wages paid on highway work in the immediate vicinity of Portland during the years 1915 to 1920:

Item.	1915.	1916.	1917.	1918.	1919.	1920.	Pctg. inc. 1915 to 1920.
Labor, day	$2.00	$2.50	$3.00	$3.50	$4.50	$5.00	150
Man and team, day	5.00	5.50	6.00	8.00	9.00	11.00	120
Trucks, hour	2.50	3.00	3.25	3.50	3.50	3.50	40
Cement, net bbl	1.90	1.95	2.79	2.79	2.79	3.60	90
Asphalt, net ton	14.50	14.00	15.55	19.50	23.50	24.00	65
Steel (reinf.), cwt	3.30	4.50	6.00	4.90	4.40	5.00	50
Lumber, M. F. B. M.	32.00	38.00	40.00	50.00	65.00	65.00	100
Powder (40%), cwt	14.00	16.43	21.50	22.25	19.75	21.05	50
Sand, cu. yd	.60	.75	1.00	1.10	1.25	1.50	150
Gravel, cu. yd	.70	.90	1.00	1.10	1.25	1.50	115
Broken stone, cu. yd.	1.15	1.15	1.25	1.45	1.85	2.00	75
Freight (25-mile haul), ton	1.20	1.20	1.20	1.50	1.50	1.90	60

Commenting on the increased cost of highway construction the report says:

A study of the average wage for labor and the average prices upon the principal materials entering into highway construction, shows that from 1915 to 1920 the daily wage for labor has advanced 150 per cent and that the prices for such materials as cement, asphalt, steel, sand, gravel and broken stone have advanced anywhere from 40 to 150 per cent, averaging not less than 90 per cent. From these figures it would appear that highway construction cost had advanced during that period about 120 per cent. As a matter of fact, however, the actual cost of highway construction has advanced even more than would be indicated by the increases in wages and prices, due to the shortage during the last two or three years of capable laborers and due to the lessened efficiency of all classes of labor as the result of the plentiful amount of work and the lack of competition among laborers.

The increased cost of labor and materials have, of course, been reflected in the contract prices upon all classes of highway work. Grading prices in particular have shown a very marked increase, excavation prices having increased in the neighborhood of 150 per cent.

Paving prices do not show as great a proportional increase as the grading prices, the increase being approximately 80 per cent. This is as would be expected, due to the fact that a very large percentage of paving costs are truck hauling and equipment costs, which costs have not increased in the same ratio as labor and materials.

Discover Unknown Substance Existing in Soil.—One of the most important discoveries in the science of soils has been made by experts of the United States Department of Agriculture within the last year in the separation of a hitherto unknown substance which has been designated as ultraclay, a gelatinelike substance, very sticky and plastic when wet and having in the dry state the general appearance of resin. It appears to be a silicate of alumina, usually with some iron and traces of potassium, sodium, magnesium, and calcium, whether combined or merely absorbed being a point not yet determined. This ultraclay is believed to be the principal factor in making the soil plastic, but when added to loose and incoherent sand in proportions up to 10 per cent, and the mixture made into briquettes and dried, it gives to the sand a crushing strength greater than an equal amount of portland cement. The briquettes made with ultraclay, however, fall to pieces when put in water, while those made with portland cement retain their form. The discovery has an important bearing upon the physical properties of soils and is being studied in co-operation with the Bureau of Public Roads as a guide in adjusting the structure of pavements to the texture of the soil on which they are built.

Pavement Cutting by Pneumatic Machinery

With the many improvements which have been made in pneumatic machinery it is now generally considered an unnecessary expense to cut asphalt, concrete, or bithulithic pavement with a pick or chisel and sledge. Not only is the hand method laborious and slow, but it is wasteful, in that quite often the opening is larger than is necessary. The pneumatic method of making pavement cuts is described by Mr. Linwood H. Geyer in the February Compressed Air Magazine, from which the matter following is taken.

For asphalt and bithulithic pavement cutting the tool in general use is a pneumatic machine bitted with a sharp bladed chisel. The method employed is: first a marking is made by sliding the chisel along a chalked cutting line; next the chisel is used to cut down and through the paving, and lastly, the same chisel is used to pry up the slab to be removed. Although in many cases a heavy chipping hammer has been used for this work it has been found advisable, where the extent of the work permits, to use machines which are specially adapted for this service. Large public service corporations and city paving contractors are constantly confronted with the removal of road surface, for pipe and conduit trenches and for pavement repairs. A number of these companies are now using a machine known as the "Paving Breaker." This machine is non-rotating and operates on the same principle as the hammer drill. It can easily be handled by one man. Shanked steels with moil or chiseled bits are used to break up the paving, the steel being held in the machine by a steel retainer.

In cases where such work only occurs at infrequent intervals, contractors, having "Jackhamers" as a part of their regular equipment, remove the rotation elements from these drills and use them with a bull-point steel.

Electric railway companies have long since adopted the pneumatic tie tamper as the most satisfactory way to tamp their track. In many cases road surfaces, which must be maintained by the street railway company, are torn up by using the tie tamper with a chisel bit—although many of these same companies are now standardizing on the "Paving Breaker" because of the larger quantity of this work which must be done, during all seasons of the year. These same companies often use their tie tamper compressor cars for supplying the air, although electic driven wagon portable compressors are frequently used.

Paving Breakers Used for Breaking Up Asphalt and Paving Blocks for Pipe Trenches and Street Railway Construction and Repairs.

Significance of Local Conditions in Design of Brick Pavements*

By MAURICE B. GREENOUGH,

Secretary, National Paving Brick Manufacturers' Association

We hear and read repeatedly that "local conditions" need to be reckoned with in the design and construction of pavements. Now, constant repetition emphasizes some thoughts and adds clarity to their meaning scope or application, in practical ways. To the contrary, there are numerous excellent propositions that are made increasingly vague by continual reiteration. It is much to be feared that the term "local conditions," as used in paving engineering, falls into the latter class. The more the expression is used the less real meaning it conveys!

Experience has, with all of us, very much to do with our conception of what "local conditions" denotes. Accordingly, we may have concluded that problems associated with financing improvements are of paramount importance, or perhaps those of location or traffic or subsoil and foundation, or any one of several phases of the question.

The Illusive "Standard" Type.—The fact remains that each of us reads into our conception of "local conditions" a meaning that harmonizes with our own experience. There has been no procedure, established by professional custom or agreement, that constitutes a well-rounded guide for the identification and solution of such matters. That such a statement can be made is unfortunate, but not surprising.

Let us recall for a moment that not so long ago efforts were being made to create "standard" types of paving that could be used universally, with as much economy in one place as another. All this effort, if it had any justification, must have rested upon one assumption, and no other, that conditions found surrounding each and every proposed paving project, likewise were standardized. As well attempt to equip all men with the same size and kind of shoe! As feet vary, so do all the details of different paving projects.

When adherence to "standard" types prevailed the adoption of any paving type, other than so-called standard, could be had only by proving conclusively that the "standard" type could not meet the situation. The burden of proof had to be assembled to support the negative of the proposition.

There could have been but one outcome for street and highway building if the pursuit of the (now recognized) illusive "standard" had continued. That would have been the failure of so large a proportion of paving improvements that expense, citizens would have turned away from such things. They would have denied themselves the benefits of paved thoroughfares because of the price, in waste and inefficiency, they would have been compelled to pay.

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*Paper presented Jan. [illegible] at [illegible] annual meeting of the Illinois Society of Engineers.

True Designing.—Happily, the trend of engineering practice today in paving design is away from the use of "standard" types of paving and toward the selection of forms of paving, of all kinds, that best satisfy the requirements of the particular project for which paving is being chosen. This indicates that, however seductive might have been the appeal of uniform treatment for all paving improvements, it could not prevail against the conservative engineering thought which would build structures suitable to the needs of given situations. If one may gage the progress of engineering sentiment and classify it while yet it is in a state of change, one would say:

First—That eventually as much care, in proportion to the nature of the work, will be bestowed upon the examination of a proposed paving project, in securing the fundamental data necessary for economic designing, as would be exercised in securing facts for the design of bridge piers or high building foundations,

Second—That where two or more pavements as designed and built happen to be similar in all respects, then it will be because the basic situations surrounding each of them likewise happen to call for the same treatment

Brick Pavements Analyzed.—Admittedly, the design of pavements by the method of assembling all pertinent data, and the selection of a type based upon the consideration of all the available resources, imposes a volume of work upon the designing engineer larger than alleged "designing" by the adoption of some "standard." But we believe that whatever additional effort is required to be put forth more than justifies itself to engineers who would use public money to the best advantage.

Let us now consider the possibilities of brick pavements as to the available types of construction. A brick pavement is a composite structure. It has three elements:

Wearing surface
Bedding
Foundation.

The relation between these several elements is most clearly defined, and the necessary data for design assembled beginning the analysis with the foundation.

The Foundation.—By foundation we mean the natural soil underlying the pavement plus the artificial base, if such proves to be required. The two must be studied as one element. Where the natural soil is high in the properties ascribed as essential in upholding the pavement structure, namely well drained and therefore probably stable, less requirements are exacted from an artificial support. Conversely, where the natural soil seems unsuitable for the performance of its proper functions, one or two courses is open to the designer.

He may take steps to improve the character of the subsoil or he may throw all the burden of pavement support upon the artificial base.

The comparative values of the alternate methods may, we believe, be summed up thus: If the subsoil is favorable to the performance of its functions, then the burden of supporting the pavement, and its loads, is thrown upon the natural earth. The artificial base primarily serves as a medium for the transmitting of loads and forces from the wearing surface to the natural foundation where they are fitly disposed of. On the other hand, if the subsoil is not capable of rendering proper service, then all the capacity for pavement support, and everything which that entails, must be provided for in the artificial base.

As a matter of practical record, we have had sufficient evidence presented to us in the recent past (and doubtless we shall have more in the future) to show that recourse to this last procedure results only in waste and inefficient pavement construction. We must then build our pavement bases as bridges, and the cost of such construction as would accomplish what is intended, would be prohibitive, even if it had the justification of good sense. We know that in the long run it is cheaper to improve deficient subsoils, once and for all, than it is to repair broken down pavements. Of the two methods, the first is obviously the more to be desired.

Let the foregoing discussion serve to establish the need of a most thorough subsoil study in each case of brick pavement design. The strong and weak characteristics of the soil will be disclosed thereby which will guide the selection, and the proportioning, of the artificial support. By this method, we establish whether or not an artificial base is needed, and if so, substantially how much of a given kind of base is required to meet the situation.

With this general analysis in mind, it is now opportune to point out the fact that there are many forms of artificial bases adequate, under proper conditions, for brick pavements, for example, concrete, hardened or green; rolled stone, gravel or slag, screenings or bituminous bound; and worn macadam or concrete pavements. A selection from these bases is available for any project under consideration. And the speaker would re-emphasize an opinion already expressed before this society, that he believes that single projects may, in time, be underlaid with several types of bases according to the nature of the natural foundation.

With brief reference to the fact that there are many cases where no artificial base is required, let us dismiss the question of the base and proceed to a discussion of the bedding.

The Bedding.—In this element of a brick pavement, we have the medium that serves, like the artificial base under proper conditions, to transmit loads and forces, and probably to absorb a certain amount of them, fractional of the total at the most. The bedding likewise is a construction expedient, to furnish, as the name implies, a convenient resting place for each brick so that its position is consistently secure with reference to other brick, and likewise with reference to surface elevation. The bedding is a means of securing a smooth surface.

Experience shows that the bedding is an important factor to be considered in brick pavement design. Foundation may be studied and base selected (and subsequently built) with the greatest skill and economic good judgment. But if the bedding is not in proper accord with the rest of the structure, a successful pavement may not be had. The controlling consideration is the composition of the filler between the brick.

If the filter is of a kind, like asphalt or sand, that permits slight movements or readjustments, under traffic, of any single brick without reference to a change in position of any other brick, then the bedding must likewise permit this movement. If, on the other hand, the filler is cement grout, and the movement is of the surface acting as a slab, then the bedding must likewise be of a character to act similarly, over an area equivalent to the affected area of the wearing surface.

The general practice of engineers today is to use sand and similar materials in conjunction with bituminous and sand fillers. Where the filler is cement grout, one of two methods may be followed. The bedding may become one with the base, as when the brick are laid in green concrete, or a cement-sand bed may be used.

Thus the distinction is drawn between "flexible" and "rigid" brick pavements. As to the effect on the artificial base, it may be said that the use of cement grout filler predicates the adoption of a concrete base and thus creates a "rigid" type of pavement, while many other bases, in addition to concrete, are available for the "flexible" types. To none, by any means, may be awarded a place as "standard."

Some Fundamental Principles.—If the terms "flexible" and "rigid" do not convey an adequate picture of the distinctions in type involved, let it be said that, with the former, the wearing surface is relieved, in some measure, of the load-supporting function. In the case of the latter, the wearing surface, bedding and foundation, united as they are in a solid slab, must of necessity, share each in some measure, at least, in the structural reactions of the pavement as a whole. And the assertion may be ventured that, with the "flexible" type of pavement, less base compared with the "rigid" is needed, if loads are properly transmitted to suitable subsoils.

The development of the practice of using brick 3 in. deep with a "flexible" filler, rests upon the above distinctions. And so we find, in most instances, brick of the 4-in. depth used in the rigid types of construction. But the fundamental principles already mentioned as involved in the competency of subsoil support are identical in application to the two types. The better the support from the subsoil, the less of artificial provision for it needs to be made, in the structural assembly of the pavement. And of course that means more economical designing, and hand in hand with better designing, the conservation of funds thus effected, and more efficient service from the pavements when built.

We believe that it is self-evident that if there is any virtue in our analysis, types of construction of brick [illegible] are not lightly to be selected. We must bear in mind that the chief attainment sought is the maintenance of the wearing surface of the pavement (every pavement) in a normal position for the performance of its service. We are not vitally concerned with how this is accomplished provided it is done.

We need wearing surfaces for our pavements which possess endurance in proportion to all possible future demands of traffic. Correctly built brick pavements are enduring under traffic and the brick themselves are practically immune to the disintegrating influences of natural forces like water and frost. The principles of good designing might therefore be laid down about as follows:

First—Let the subsoil be studied exhaustively and its probable behavior catalogued, from one end of the project to the other.

Second—Let the nature and proportions of the artificial base be determined only after the filler to be used has been settled upon. Also, after a painstaking search for, and selection of, the materials which will, at the least cost, insure the satisfactory performance of the requirements of the base. Maximum serviceability at minimum cost!

Third—Let us not be hesitant at including more than one type of construction in a single improvement project, if conditions found indicate the wisdom of doing so.

Fourth—Let every step in this preliminary study and search for fundamentals be made a matter of accurate public record in every detail.

Fifth—And finally let us build with that exactitude and care which will impart to the completed structure all the service quality which is the inherent property of each and every material entering into it.

Actual Study.—And now, has all this discussion a practical bearing upon pavement design? We believe it has. If, instead of assuming, broadly and without detailed study, that a particular form of brick (or any other pavement) will answer the purpose for every paving project and then saying that "local conditions" may perhaps modify the choice, we study all such conditions and evolve the best type we can in each instance, no one, we believe, will deny that progress will have been made in connecting up type of construction and service. That means better paving for the taxpayers' money. Our chief objection to the thoughtless use of the expression "local conditions," and none will gainsay the prevailing, if diminishing, prevalence of the custom, is that it leads directly to loose thinking and still looser designing. What we need most is an appreciation, not of comparative "local conditions" but of absolute local conditions. Paving types selected in this attitude of mind will meet their service requirements because they are built for the conditions as and where they exist and not for some location 50 miles away.

Advantages of Machine Cleaning of Cement Sacks

A saving of $1,000 was effected in a road building season by the use of a machine for cleansing cement sacks, according to an article by George M. Gross, Road Contractor, La Porte, Ind., in the Contractors' Atlas. The machine was bought in the spring and during the season it cleaned 100,000 sacks, securing from them approximately 200 bbl. of good, first class cement.

In addition to the cement saved, the reduced weight of the sacks made freight charges on the return shipments only about half what they had been with the uncleaned sacks. In fact, the bundles weighed on an average, when cleaned, 25 lb. per bundle of 60 sacks as against 50 to 75 lb. per bundle when not cleaned.

Another was that when the sacks had been through the cleaner, there was no trouble in reading the owner's name on the sack which avoided the shipping of some of the sacks to the wrong place. On this job they were using seven brands of cement, and before we started using the cleaner, a good many errors were made in returning the sacks to the cement manufacturers.

Maryland County Cuts Road Wages.—The Commissioners of Montgomery County, Maryland, have reduced the wages of laborers on road work from $4 to $2.50 per day.

Results of Traffic Censuses on Pennsylvania Highways

An investigation made by the State Highway Department of Pennsylvania shows that a total of 773,604 tons annually is sent over the Lincoln Highway between Philadelphia and Trenton. This tonnage is equal to 19,300 steel hopper cars containing 40 tons each. These cars would make up 275 freight trains. The distance covered by the Lincoln Highway in Pennsylvania east of Philadelphia is 14 miles; hence the ton mileage represented in one year is 10,830,456. Commercial vehicles comprise 56 per cent of the traffic on this section of the Lincoln Highway. These figures are based on an hourly census taken for two weeks by the State Highway Department.

The department has also taken a census of traffic on Route No. 34, between Harrisburg and Carlisle. It is found that 63 per cent of the traffic on this thoroughfare is composed of passenger vehicles.

The construction on Route No. 34 is waterbound macadam; on the Lincoln Highway in Bucks County, waterbound macadam.

In order properly to coordinate the values, it was deemed advisable in this census to assume that the average weight of touring cars is 2,000 lb. It is found that the total yearly census reduced to ton mileage upon the highway between Harrisburg and Carlisle is as follows:

	Number.	Tonnage.	Ton mileage.	Percentage based on tonnage.
Roadsters and touring cars: Total	249,080	249,080	3,736,200	63
Trucks: 1-ton	16,432	16,432	246,480	37
2-ton	14,300	28,600	429,000	
3-ton	10,660	31,980	479,700	
4-ton	8,372	33,488	502,320	
5-ton	7,280	36,400	546,000	
Truck total	57,044	146,900	2,203,500	
Grand total	306,124	395,980	5,939,700	

It is interesting to note that 63 per cent of the total ton mileage that passes over the Harrisburg-Carlisle road is touring cars and 81 per cent by number of vehicles. In other words, only 19 per cent of the traffic by numbers is composed of trucks. On the Philadelphia-Trenton highway 44 per cent of the total ton mileage is touring cars, although this equals 74 per cent of the number of vehicles. This is accounted for by the number of large trucks continuously using this highway for freight transportation. Figures for the Philadelphia-Trenton road, otherwise known as the Lincoln Highway, are as follows:

	Number.	Tonnage.	Ton mileage.	Percentage based on tonnage.
Roadsters and touring cars Total	339,924	339,924	4,758,936	41
Trucks 1-ton	19,422	19,422	271,908	56
2-ton	14,170	28,340	396,760	
3-ton	15,834	47,502	665,028	
4-ton	16,224	64,896	908,544	
5-ton	54,704	273,520	3,829,280	
Truck total	120,354	433,680	6,071,520	
Grand total	460,278	773,604	10,830,456	

Another highway upon which the department has kept a close traffic census for the last year is Route No. 221, Blair County, north of Altoona. This road is used extensively for hauling coal and records show that 86 per cent of the total ton mileage carried over this road is by trucks, while 38 per cent by numbers is touring cars. Figures for this route are as follows:

	Number	Tonnage	Ton mileage.	Percentage based on tonnage.
Roadsters and touring cars Total	60,135	60,135	300,675	14
Trucks: 1-ton	2,945	2,945	14,725	86
2-ton	13,718	27,436	137,180	
3-ton	30,818	92,454	462,270	
4-ton	22,838	91,352	456,760	
5-ton	16,587	82,935	414,675	
6-ton	12,426	74,556	372,780	
Truck total	99,332	371,678	1,858,390	
Grand total	159,467	431,813	2,159,065	

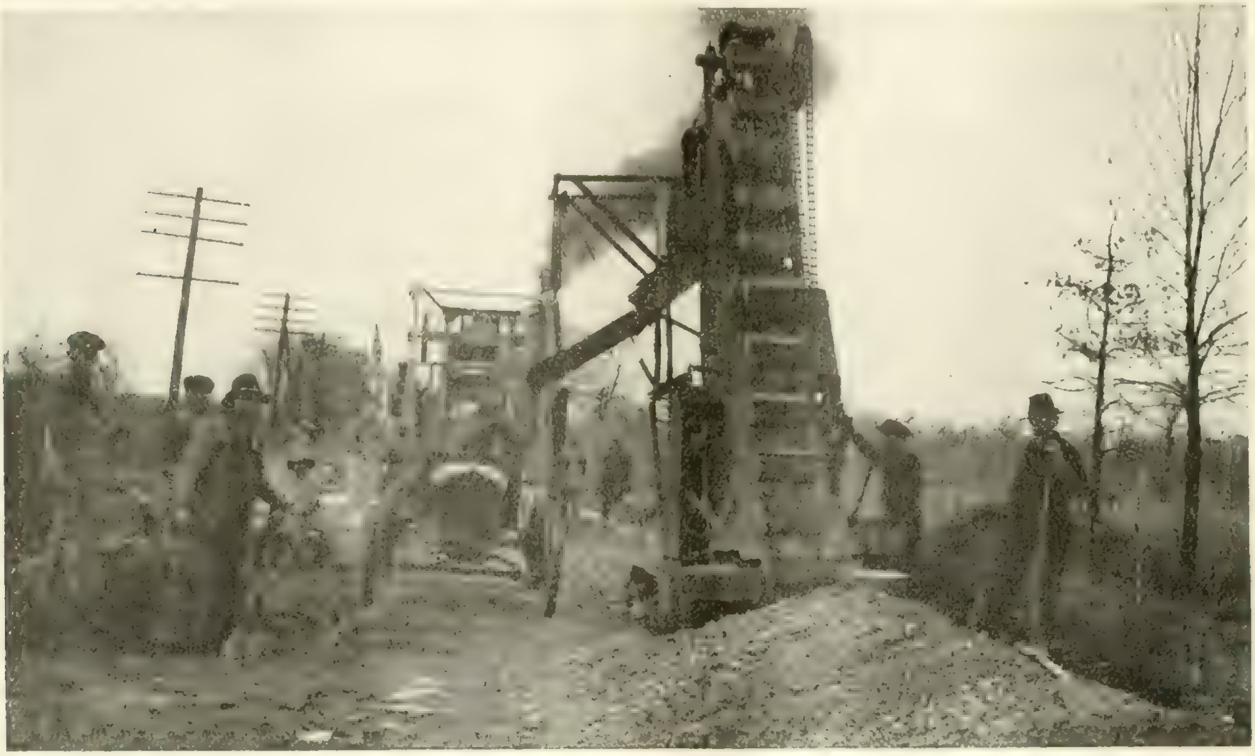
The Lincoln Highway census shows the yearly truck tonnage for 1-ton trucks is 19,422; 2-ton trucks, 28,340; 3-ton trucks, 47,502; 4-ton trucks, 64,896; 5-ton trucks, 273,520. The total truck tonnage is 433,680. The total passenger car tonnage is 339,924.

Low hours for the day on truck traffic are shown to be from 11 p. m. to 1 a. m. The greatest truck traffic occurs between the hours of 7 and 8 a. m. and 4 to 5 p. m. The heaviest passenger car traffic occurs between the hours of 4 and 7 p. m., but it runs into large numbers between the hours of 10 a. m. and 3 p. m.

Machine Handling of Concrete Road Materials

Regardless of what other conclusions may be drawn from the past season's experiences in concrete road work it is safe to say at this time that the days of handling material on this class of work by hand are past and that the contractor who expects to meet the competition, cut costs, and show earnings in place of losses now feels that the material handling equipment which has proved satisfactory for road work is just as essential to the success of the work as is the concrete mixer itself. In other words the man who has used the proper kind of material handling machinery would no more go back to the general practice of using shovels and wheelbarrows than he would abandon the mixer and replace the mixing board.

During the past season studies were made of concrete road jobs on which Barber-Greene self-feeding bucket loaders were used. Table I summarizes briefly the net results of using this equipment in various ways.



Loading from Central Storage on R. F. Conway's Chicago-Wisconsin Road Job.

TABLE I.—COST OF HANDLING CONCRETE ROAD MATERIAL.

Contractor.	Location of work.	Width and thickness.	Results—Average feet per day	Unit costs of handling material per sq. yd. By machine.	By hand.	Savings effected by machine handling.
R. F. Conway, Chicago, Ill.	Chicago-Joliet Road.	18 ft.; 8 in. center; 7 in. edge.	450 ft.; 9 hrs.; four bag mixer.	$0.023	$0.056	$0.033
R. F. Conway, Chicago, "	Chicago-Wisconsin Road.	18 ft.; 7 in. center; 6 in. edge; 4"x3" curb.	400 ft.; 9 hrs.; four bag mixer.	.027	.070	.043
R. F. Conway, Chicago,	Chicago-Wisconsin Road.	18 ft.; 7 in. center; 6 in. edge; 4"x3" curb.	735 ft., 8 hrs., two 4 bag mixer.	.015	.076	.061
Commonwealth Improvement Co., Chicago, Ill.	Higgins Road near Elgin.	18 ft. 7½ in. center, 6½ in. edge.	300 ft.; 10 hrs.; four bag mixer.	.102	.183	.081
Badger Const., Milwaukee, Wis.	Fonda, Ia., street paving.	Various widths, 5 in. thickness.	700 ft., 9 hrs., two bag mixer.	.027	.081	.054
Schmidt Const., Chicago, Ill.	Chicago alleys.	[illegible] ft. 4 in. wide, 7 in. thick.	500 ft.; 8 hrs.; three bag mixer.	.113	.24	.127
Badger Const., Milwaukee, Wis.	Fonda, Ia., street paving.	Various widths, 5 in. thickness.	500 ft.; 9 hrs.; two bag mixer.	.0287	.082	.053
James Horrabin & Co., Des Moines, Ia.	Des Moines, street paving.	30 ft. wide, 5 in. thick.	750 ft.; 9 hrs.; three bag mixer.	.058	.114	.056

Conway Work—Chicago-Joliet Road.—On this work, the stone was picked up from subgrade by a Barber-Greene self feeding bucket loader, discharged from the measuring hopper of this machine into a Lee body on a Ford truck which hauled it approximately 50 ft. to the mixer. The sand was loaded by hand.

Conway Work—Chicago-Wisconsin Road.—On this job the stone was loaded from a central stock pile with the bucket loader equipped with measuring hopper and hauled to the mixer in Lee bodies on Ford trucks. A bucket loader was also used on sand in the same way. The average haul to the mixer was 1½ miles.

Commonwealth Improvement Co.—Higgins Road.—The stone and sand on this work were hauled by trucks from a nearby pit and stored in alternate piles on the subgrade. Two self feeding loaders with measuring hoppers were used to load the sand and stone into two Clark tructractors which hauled the material to the mixer at an average distance of a little more than 100 ft.

Badger Construction Co.—Fonda, Ia.—Two self feeding loaders were used on this work in connection with Clark tructractors operating at a central stock pile. The tractors carried the material to the mixer located about 100 ft. from stock piles and the wet concrete was then hauled to the streets in Ford trucks with Lee bodies. The maximum haul was ¾ mile.

Schmidt Construction Co.—Chicago Alleys.—The sand and stone on this work were stored in piles on pavement at intersections. Two bucket loaders loaded the material into Clark tructractors which carried it to the mixer located 200 to 350 ft. from stock piles.

James Horrabin & Co.—Des Moines, Ia.—The sand and stone on this work were piled at street intersections and on the subgrade. A self feeding bucket loader loaded the stone into dump carts and the sand was shoveled into the carts by hand. These carts were drawn by single horses, the distance to the mixer ranging from 100 to 600 ft.

The How and Why of Truck Impact

The impact forces brought to bear on modern highways by heavy motor trucks have for some time occupied a large share of the attention of highway engineers. The study of these forces, their amount and character and the more accurate determination of their effect on highway surfaces is one of the major subjects under investigation by the division of tests of the Bureau of Public Roads. In the November issue of Public Roads the official publication of the Bureau, Mr. Earl B. Smith, Senior Assistant Testing Engineer of the Bureau, presents an analysis of the action of the various parts of the motor truck as it passes over the road, and of the effect of the several parts in producing impact and pressure forces which are applied to the road through the wheels. The matter following is taken from his article.

Two Loaders on Subgrade on Commonwealth Improvement Co.'s Higgins Road Job.

Factors Which Produce Impact.—The impact which results when the moving truck strikes an obstruction on the road or passes over such surface irregularities as waves, potholes and joints, is a function of several factors, most of which originate in various parts of the truck. These factors are: The sprung weight, or all weights and loads above the springs; the unsprung weight, which includes wheels, tires, axle springs, and all other effective weights, under the spring; the kind and condition of the tire; the spring characteristic which is its deformation or deflection under different loads and its period of vibration; the horizontal speed of the truck; and the character of the road surface involving the size and shape of the obstructions or irregularities over which the wheel passes.

To deal first with the last-named factor, the irregularities and obstructions presented by the road surface must share responsibilty with the irregularities and defects of the tires as the prime cause of whatever impact is produced. Given a perfectly smooth road surface, traveled by a truck with perfectly smooth circular tires and there would be no impact regardless of the truck's weight and speed. But since perfect smoothness of either road or tire is a condition it is practically impossible to attain, it follows that impact must be recognized as an inevitable force and its destructive effects may be reduced by proper design of the road and the truck.

In general, the effect of increasing the horizontal speed of the truck is to increase the impact. The belief formerly held that the impact would vary as the square of the speed is not borne out by careful investigation. In the tests made thus far it has been observed that the intensity of the impact has varied with some power of the speed, but this power is less than two and may be as low as one. Indeed, under some conditions, as when the truck is projected over the edge of a horizontal section of pavement and falls to a lower section the impact may be practically independent of speed.

The factors of speed and surface and tire irregularity may be regarded as the factors which create the conditions resulting in impact. The quality of the impact and the intensity of it are naturally affected by the relations of sprung and unsprung weight, the character of tires, and the characteristics of the spring used in the design of the truck itself.

Since impact is the force resulting from a mass being moved or brought to rest with a certain acceleration, it is greatest when "mass times acceleration" is a maximum. Whatever adds to mass or acceleration tends to increase impact and whatever is done to reduce mass or acceleration will tend to decrease impact.

The Effect of the Springs.—In dealing with motor trucks the total mass is really made up of two masses which are separated from each other by a spring. If the whole mass falls free from some considerable height (that is, several feet) its net acceleration will be that of gravity, but the negative acceleration at the moment of impact will not be the same as if the truck were a single solid mass. This is the result of the cushioning action of the springs which reduce the declaration of the sprung parts. In this case the sprung parts really do not add to the impact of the unsprung parts, but rather produce intensified pressure a moment after impact when the spring deflection reaches the maximum. This action of the spring has simply reduced the deceleration of a part of the mass and thereby decreased the impact effect from what it would have been if the whole acted as a single rigid mass.

Now, let us suppose that the truck be supported at a height of only 3 in. above the road instead of several feet as in the former example, and suppose that the deflection of the spring under the weight of the part of the mass above it is greater than 3 in. If, then, the whole mass is dropped by releasing that part of the mass under the spring this unsprung mass will be accelerated downward by the combined effect of gravity and spring pressure with the result that it will have a very high velocity and be brought to rest very suddenly upon striking the pavement. This downward velocity and final deceleration may be very much greater than could be obtained by a free fall from a height of several feet. In this case the sprung mass has dropped very slightly but the initial compression of the spring has increased the velocity of the unsprung parts and thereby increased the impact produced by those parts.

Again, suppose that instead of supporting the truck at a height above the road which is less than the spring deflection, it is supported at some height somewhat greater. Now, if the unsprung weight be suddenly released, the whole mass drops but the unsprung parts by virtue of the propulsion of the spring will at first be accelerated faster than the mass as a whole. Then if the drop is sufficient to permit the spring to reach the limit of its oscillation before the wheels strike the road, the effect will be to decrease the velocity of the unsprung parts, relative to the whole mass, by the reverse action of the spring. In this case the action of the spring may actually serve to reduce the impact of the unsprung parts.

Thus it is seen that the springs of a motor truck tend to reduce the impact of the truck as a whole by reducing the vertical deceleration of the sprung parts; that under some circumstances they may reduce the velocity of the unsprung parts, but that under most actual conditions they may tend to increase impact by adding to the velocity of the unsprung parts. Their effect upon the impact in any case, is through the modification of the declaration of the sprung and unsprung portions; this effect on the unsprung portion being due to a change in the vertical velocity at the beginning of impact.

The Effect of the Tires.—Having analyzed the action of the spring in this way, let us now examine the effect of the tires. The tires are designed to do for the unsprung parts what the spring does for the sprung parts, i. e., to reduce their vertical deceleration. The extent to which they accomplish their purpose depends upon their abilty to deform or yield under the blows of the truck above them. The harder they are the greater will be the acceleration or deceleration of the truck mass, and the less will be their effect in reducing impact. A wheel tired with hard rubber, upon striking an obstruction on the road surface will produce relatively great impact, because it is only slightly cushioned by the tire, and is brought to rest in a very short space of time. If the same wheel be fitted with a softer tire the impact will be smaller, and its value will be a function of the deformation of the tire. Herein lies the advantage of pneumatic over solid rubber tires.

The Truck in Motion.—In the foregoing discussion the action of the springs and tires has been studied under conditions of free fall from an initial state of rest. The question which will naturally arise is, do these conditions pertain to the action of the truck when it is moving over the road? What actually happens when a truck moves over a road? In the first place, the wheels are continually rising and falling as they encounter obstructions or irregularities in the road surface. At the same time the tires are alternately in a state of compression and release. The unsprung parts follow the wheels, rising and falling more or less sharply according to the kind and condition of the tires. The motion of the unsprung parts is transmitted to the sprung parts through the spring which oscillates up and down under the repeated blows of the axles. Such is the effect of the springs, however, that the motions of the sprung parts are much less abrupt than those of the unsprung parts. Their rising and falling occupies a longer period, and because of this difference in the period of oscillation, at any instant the sprung and unsprung parts may be rising or falling together or the one may be rising while the other is falling.

The movement of the sprung parts when the wheel strikes an obstruction is comparatively slight at the instant of striking. Their period of vibration, because of inertia, is rather long in comparison to the period of the unsprung parts. The displacement or maximum movement of the sprung weight occurs at some time after the impact, and produces intensified road pressures, which may be greatly more than the total load of the truck.

The unsprung parts act in an entirely different manner. When the wheel strikes an obstruction in the road it acquires an upward velocity depending upon the height of the obstruction and the speed of the truck. The reaction on the road surface is a force depending for its value upon the maximum vertical acceleration of the wheel, the mass of the unsprung parts and the spring pressure. The wheel may continue to move upward even after passing the obstruction, until the movement is overcome by spring pressure and inertia. It is then shot downward by the combined action of gravity and spring pressure, and thus produces another impact on the road surface. The vertical reaction of this upward movement of the unsprung parts serves to retard slightly the fall of the body or sprung parts of the truck, and when this body does fall it is partially cushioned on the spring, and does not really produce an impact; but it does produce an additional pressure on the road surface somewhat like that of a suddenly applied load, which, as mentioned above, may be greatly more than the weight of the truck.

It will readily be seen that the magnitude of the impact as the wheel passes over obstructions is dependent upon the speed of the truck. It is the unsprung weight and the value of the spring pressure which produces the actual impact. The greater the spring pressure and the greater the unsprung weight the greater will be the impact. The movements of the sprung weight do not actually result in impacts, but in intensified pressures. As a factor in producing spring pressure, however, the sprung weight does add to the impact of the unsprung weight.

From these statements it may be seen that while the weight of the unsprung parts is a direct factor in the resulting impacts on road surfaces, it is not necessarily true that the heavier unsprung weights produce always the greatest impact. On the contrary, conditions may be such, with a light unsprung weight, on hard, nonresilient tires, under the influence of large accelerations or decelerations, that high impact values will be produced. It should be noted that this discussion of the effect of unsprung weights applies only to impacts on road surfaces and not to the effects produced on the truck itself.

The Effect of Mass.—Up to this point the attention has been centered upon the parts of the truck which affect impact through their effect upon the "acceleration" factor. The springs and tires reduce impact by reducing acceleration. It is obvious that the only other means of reducing impact is to reduce the mass of the truck, or since the impact is delivered through four wheels, to reduce the mass on any wheel or pair of wheels. In this direction lies the possibility of a considerable further reduction of impact, because motor trucks, as now designed, generally carry the larger part (up to 90 per cent) of their weight upon the rear wheels. In the average heavy truck the body is nearly balanced upon the rear axle. Normally a small amount of the carried load goes to the front wheels, but so near is the balance on the rear axle, that a slight eccentricity of loading will often result in decreasing the load on the front wheels. The effect of the truck upon the road surface depends upon the impact delivered by its heaviest wheel. It follows, therefore, that a substantial reduction in the destructive effect of the truck can be made by distributing the load more uniformly to the front and rear axles, thus reducing the load on the rear wheels.

This change alone would go far to reduce the heavy burden laid upon the public in the shape of repair bills for roads damaged by motor trucks. What else can be done? Roads can be kept smoother by better maintenance, though in the nature of the case they can not be kept so smooth as to eliminate impact entirely. Solid rubber tires can be kept in better repair, or better still, abandoned in favor of cushion or pneumatic tires wherever possible. Operating speeds can be kept within reasonable limits. Such measures will reduce the intensity of the destructive force. Whatever impact remains when these things have been done is the force which it is the duty of highway engineers to provide against in the design of future highways.

Gravel Road Construction in Two 2-in. Courses

In constructing the Fremont-Cresco Federal Aid Road in Nebraska a method of surfacing has been employed that is a departure from this generally accepted manner of building a gravel road. The following particulars regarding this work are taken from the October report of the Department of Public Works of Nebraska.

The road is 33 miles in length.

When the work of graveling was started, the gravel was hauled in army trucks, allotted to the state by the Government. These trucks were equipped with dump bodies, and hauled an average of 2¼ cu. yd. per load. The gravel was excavated from a bank pit, with an auto crane, equipped with clam-shell bucket. Later Troy trailers were used in a train of from 8 to 10, each trailer having a capacity of approximately 4 yd. The size of the load was governed by the condition of the road, and the steepness or rutty condition of the surface.

One of the most important facts developed during construction was that the gravel must be spread in two courses of 2 in. each, thereby enabling the first course to rut into the surface of the road, and become thoroughly compacted before the second course was applied. By this method, a more compacted and smoother surface resulted than could possibly have been secured by applying one 4-in. course at a time.

Constant dragging is necessary with this type of surfacing, and especially during the time the road is compacting. An abundance of rain also will aid the process and insure a smoother surface. The traffic ruts in the gravel, but continues only for a short time, for as it dries the rutting ceases and the road surface commences to smooth out under the general traffic, and the care that is given it at this time, of dragging and blading. The traffic is as essential as the periodic dragging, and the one assists the other.

Utilization of Old Macadam Roads

By R. W. PARKHURST.

Experience has proved that the manner in which most waterbound macadam fails, seems to indicate in the general case, that such failure is not due to any inherent weakness of construction, but solely to the inability of the wearing surface to meet travel requirements. In other words, the construction ordinarily is strong enough to support traffic, and only requires a proper surface to provide an admirable highway. Before such waterbound macadam can be utilized as a base for a so-called permanent highway, several features must be considered which are directly related to the three elements comprising any highway, namely; subsoil, base or foundation, and wearing surface.

These elements, properly analyzed, show that the weight is ultimately carried by the ground or subsoil, which to support such weight adequately, must be firm and well drained The base or foundation must be of such character as properly to distribute the weight of traffic to the subsoil in order that the allowable maximum may not be exceeded. The wearing surface takes only the abrasion of traffic, and transmits the load directly to the foundation and base beneath.

In a waterbound macadam road which has been in use for some time, the distinction between wearing surface and base will have very nearly disappeared, and theoretically there can be no objection to the use of the entire macadam roadway as a base providing it can perform the function of distributing the weight of traffic, and is of such character as to resist disturbing influences such as frost, moisture and dislodgment or settlement.

Before utilizing old macadam as the base for a permanent roadway very careful examination of the soil condition is required. If there is evidence of clay or other waterbearing material under or adjacent to the existing macadam which results in "frost boils" and heaving of the streets in spring, in the dislocation of the curbs and in the sponginess and springiness of the ground along the road, then it would be folly to consider permanently covering the highway with an expensive surface course without first taking proper precautions to stabilize the base. This may be done in a number of different ways, such as installing sewers parallel to the curb, building cutoff drains, or performing such other operations as good engineering judgment may suggest or circumstances may demand. There will probably be cases where investigation shows the present subsoil conditions are totally unsafe, and that in order to insure permanence it would be necessary to remove the existing railway, excavate additional subsoil, and to construct deep telford or gravel foundations before laying the base and wearing surface. It should be particularly emphasized that this drainage problem is fundamental and that each situation is separate and distinct, and requires its own individual solution.

The suitability of the macadam base for use in a permanent road is dependent upon its thickness and compactness as well as on the subsoil beneath. It must be borne in mind that traffic is likely to increase in weight rather than decrease, and that hence minimum depth of foundation should be sufficient to support any travel likely to come upon it at least for the period of life of the wearing surface it is proposed to use. This requisite depth of foundation will vary with locality but in few cases has it been found in the past that a depth of less than 6 in. is sufficient. Old macadam roadways of from 6 to 12 in. in depth, other conditions being equal, offer excellent bases for permanent wearing surfaces; and it is to be noted that under some circumstances engineers prefer the elasticity and flexibility of macadam and crushed stone bases for roadways to the rigidity and comparative inelasticity of concrete, providing subsoil conditions are favorable.

The actual work of resurfacing old macadam is too simple an operation and has been too extensively employed in the past to require detailed description here. In general, however, the existing roadway is reshaped, and the depressions filled with stone, after which the whole roadway is rolled to a true grade with the required crown. If there is any scarifying to be done, that is performed before rolling, care being taken that the depth of the undisturbed portion of the roadway is not less than the establishd minimum. The following general types of wearing surfaces are usually employed; sheet asphalt or topeka-mix, and penetration or mixed-method macadam, all laid in the usual manner over the firmly rolled and graded macadam base. Experience has shown that a roadway of permanent character may be built in this way; roads constructed of native-lake asphalt from 5 to 10 years ago in certain regions adjacent to New York City are still in excellent condition, and to date have required no maintenance.

In a general way, the cost of such resurfacing will be found to be less than construction of new work; in fact this resurfacing to all intents and purposes is now obtained at from one-half to two-thirds the cost of completely reconstructed highway. Not only is the cost very largely reduced, and hence the expense to the taxpayer cut down, but the original highway investment is conserved and made of further usefulness to the community.

The Chicago Good Roads Congress and Machinery Exposition

Several thousand highway officials, engineers and contractors are expected to attend the good roads congress and machinery exposition which will be held Feb. 9 to 12 at the Coliseum, Chicago, under the auspices of the American Road Builders' Association. All sessions of the convention will be open to the public. The tentative program includes the following:

Wednesday, Feb. 9th, 9 A. M.

Registration of delegates and distribution of programs and badges. Entire day, headquarters, Chicago Coliseum.

FIRST SESSION.

Convention Hall, Coliseum, 10 A. M.

H. L. Bowlby, Chief, War Materials Division, U. S. Bureau of Public Roads, Washington, D. C., presiding.

Meeting called to order by the president of the American Road Builders' Association, M. J. Faherty, Chicago, Ill.

Invocation.

Announcement of convention committees.

"Our National Road Problems," Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads, Washington, D. C.

"Relation of the Highway and Motor Transport Movement to Education," Prof. C. J. Tilden, National Director of Highway and Highway Transport Education, Washington, D. C.

"Highway Improvement in New England," by A. W. Dean, Chief Engineer, Division of Highways, Massachusetts Dept. of Public Works.

"The Local and National Importance of the Lee Highway," by Dr. S. M. Johnson, Manager, Lee Highway Association, Roanoke, Virginia.

RECESS.

SECOND SESSION.

Convention Hall, Coliseum, 2 P. M.

George C. Diehl, County Engineer, Erie County, New York, presiding.

"The Higway's Part in the Development of Efficient Transportation," by C. W. Reid, Chairman, Transportation Committee, Federal Highway Council, Washington, D. C.

Discussion—T. J. Wasser, State Highway Engineer of New Jersey.

RECESS.

MASS MEETING.

Medinah Temple, 8 P. M.

Michael J. Faherty, President, American Road Builders' Association, presiding.

Musical program, Great Lakes Naval Training Station Band.

Address of Welcome on Behalf of the City of Chicago—Honorable William Hale Thompson, Mayor of Chicago.

Response on Behalf of the American Road Builders' Association, by Michael J. Faherty, President.

"Good Roads Movies."

THIRD SESSION.

Convention Hall, Coliseum, Thursday, Feb. 10, 10 A. M.

C. M. Upham, Chief Engineer, Delaware State Highway Department, presiding.

"Subgrades," by H. G. Shirley, Secretary, Federal Highway Council, Washington, D. C.

Discussion—Clifford Older, Chief, Highway Engineer of Illinois, and others

"Importance of Drainage in Road Construction," by F. H. Eno, Professor of Engineering, Ohio State University.

Discussion by H. S. Mattimore, Assistant Engineer, Pennsylvania State Highway Department, and others

RECESS.

FOURTH SESSION.

Convention Hall, Coliseum, 2 P. M.

J. A. Duchastel, City Manager, Outremont, Canada, presiding.

"Types of Pavement," by James H. MacDonald, Former State Highway Commissioner of Connecticut, New Haven, Connecticut.

Discussion—Newell D. Darlington, Chairman, California State Highway Commission, and Herbert Nunn, State Highway Engineer of Oregon.

"Highway Research and What [illegible]" A. T. Goldbeck, Chief, Division of Tests, U. S. Bureau of Public Roads, Washington, D. C.

Discussion—Anson W. Marston, Dean, Iowa State College.

EVENING ENTERTAINMENT.

Dinner-dance in the Gold Room at the Congress Hotel. 6 P. M. until midnight.

FIFTH SESSION.

Convention Hall Coliseum, Friday, Feb. 11, 10 A. M.

Frank F. Rogers, State Highway Commissioner of Michigan, presiding.

"Recent Development in Road Building," by Edward N. Hines, Chairman of Board of County Commissioners, Wayne County, Michigan; W. D. Uhler, Chief Engineer, Pennsylvania State Highway Department; R. Keith Compton, Chairman, Baltimore Paving Commission.

RECESS.

SIXTH SESSION.

Convention Hall, Coliseum, 2 P. M.

Howard F. Beebe, President, Harris, Forbes & Co., New York City, presiding.

"Highway Finance," by H. C. Sylvester, Vice-President, National City Company, New York City.

Discussion—H. P. Gillette, Editor, "Engineering and Contracting"; S. F. Bradt, Superintendent of Highways, Department of Public Works, and Buildings, Springfield, Ill.

EVENING ENTERTAINMENT.

Theater party at two of Chicago's leading theaters.

SEVENTH SESSION.

Convention Hall, Coliseum, Saturday, Feb. 12, 10 A. M.

Walter A. Rogers, of Bates and Rogers, Chicago, Ill., President, Associated General Contractors, presiding.

"Relation Between Engineers and Contractors," by D. A. Garber, President, Northeastern Construction Co., New York City.

Discussion—R. G. Collins, Keystone Construction Company; A. R. Hirst, State Highway Engineer of Wisconsin.

RECESS.

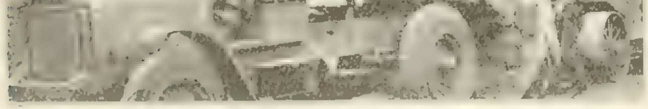
EIGHTH SESSION.

Convention Hall, Coliseum, 2 P. M.

Question Box.
Report of Resolutions Committee.
Election of Nominating Committee.
Unfinished business.
Adjournment.

2-Yd. Truck for Hauling Material Over Subgrade

A motor truck specially designed for hauling material over the subgrade in highway construction has been brought out by the Titan Truck Co., Milwaukee, Wis. The truck has a 2-yard, 5,000 to 6,000 lb. capacity, a short wheel base, 128 in., enabling it to turn on an 18 ft. wide subgrade, and a speed of 25 miles per hour on high and 5 miles on reverse. It is fitted with pneumatic cord truck tires, 36x6 in. front and 42x9 in. rear. It is stated that the distribution of the load on the trucks and the large pneumatic tires give a pressure on the subgrade of less than 80 lb. per square inch. The body is of steel construction throughout, is 8½ ft. long inside by 5 ft. wide, and is made in two compartments. It is fitted with either a hydraulic hoist or a special Titan mechanical hoist having a dumping angle of 55°. The lowest point of the body when fully raised with the Titan hoist is 29 in. from the ground. The truck has a 40 H.P. Buda motor with pressure oiling system, 4½ in. bore by 5½ stroke, 4 cylinder, and a 4-speed Cotta constant mesh transmission. The gear ratio [illegible]



2-Yd. Titan Subgrade Truck.

Personals

Adolph P. Schuck has been appointed Commissioner of Street Cleaning of Baltimore, Md., to succeed the late William A. McCleary.

Col. Frederick S. Greene has resigned as State Highway Commissioner of New York and is succeeded by Herbert S. Sisson, at present State Engineer [illegible]

Charles Andros, for the past 12 years senior assistant engineer in the New York State Highway Department, has resigned to accept a position in the U. S. Patent Office at Washington, D. C.

E. O. Hathaway, District Engineer, United States Bureau of Roads, addressed 150 members of the Twin City Chapter of the American Association of Engineers at its January meeting on Federal Aid in Road Building.

The Iowa Engineering Society at its annual meeting Jan. 18-20 elected the following officers for 1921: Prof. John H. Dunlap, of Iowa City, president; Alvin Le Van, of Des Moines, vice-president; J. D. Wardle, of Cedar Rapids, director, and Lloyd A. Canfield, of Des Moines, secretary-treasurer.

J. S. Treadway of Fort Worth, Tex., has been appointed County Engineer of Bell County, succeeding R. D. Morgan, resigned to become City Engineer and Waterworks Superintendent for the City of Temple, Tex. Mr. Treadway for seven years was connected with the Bureau of Highways for the Federal Government.

The Colorado Society of Engineers at its annual meeting on Jan. 19 elected the following officers and board of managers for the year 1921: F. C. Dreher, president; R. M. Hosea, vice-president; C. M. Lightburn, secretary; board of managers: E. A. Smith, Wm. H. Hess, J. E. Field, W. M. McMechen, J. S. Means, V. A. Kauffman, F. W. Whiteside.

Leon C. Herrick, of Norwalk, O., County Surveyor of Huron County, Ohio, has been appointed State Highway Commissioner of Ohio to succeed A. R. Taylor. Mr. Herrick is 39 years old. His engineering experience includes 3 years with the Big Four R. R., 2 years as assistant city engineer of Mansfield, O., city engineer of Norwalk, and 13 years in the surveyor's office of Huron County, during which time he was elected surveyor four terms.

Obituaries

Joseph C. Rock died Jan. 26 at his residence, 1340 Madison Ave., New York, at the age of 75, after a lingering illness of seven months. Mr. Rock was general agent of The United States Asphalt Refining Co. and was, for many years, an official of the Barber Asphalt Paving Co. He was one of the pioneers of the asphalt paving business and introduced this class of pavement in many cities in the United States 25 and 30 years ago. He also was president of a company which did a large amount of asphalt paving for the Borough of Manhattan. At the outbreak of the Civil War, although only 15 years of age, Mr. Rock joined a Vermont regiment and served throughout the Civil War. Subsequently he was connected with several government departments in Washington, and while with the Bureau of Engineering in the District of Columbia he removed to New York in 1889 to accept the post of secretary of the Barber Asphalt Paving Co. He is survived by a granddaughter, Miss Elizabeth R. Brackett, and several brothers and sisters. The interment was at Washington, D. C., Jan. 29.

Industrial Notes

The National Steel Fabric Co., Pittsburgh, Pa., has opened an Atlanta, Ga., office, in charge of H. S. Gibboney, district manager, 604 Walton building.

The Northwest Engineering Works, Green Bay, Wis., manufacturers of "Northwest" locomotive cranes, has increased its capital stock to $1,500,000 for increasing production of its crawler type crane.

The Good Roads Machinery Co., Inc., Philadelphia, Pa., has recently sold 20 Champion snow plows to the Maryland State Highway Department, 52 Champion snow plows to the New Jersey State Highway Department, 60 Champion snow plows to the Massachusetts State Highway Department and 300 Champion snow plows to the City of New York.

The Board of Directors of The Autocar Co., of Ardmore, Pa., was increased from seven to nine at the annual stockholders' meeting held Jan. 25. The old board of directors was re-elected with J. Howard Reber and Roscoe T. Anthony as the two additional new members. The directors, in session immediately after the stockholders' meeting, elected the following officers for the coming year: President, David S. Ludlum; vice-president, John S. Clarke; vice-president and consulting engineer, Louis S. Clarke; vice-president, Edwin A. Fitts; vice-president and production manager, Walter W. Norton; treasurer, Walter T. Savoye; secretary and assistant treasurer, John C. Taney; assistant secretary and assistant treasurer, Roscoe T. Anthony.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Paving Material.—Asphalt Sales Department, The Texas Co., 17 Battery Pl., New York City. Portfolio entitled "What Is Your Highway Problem?" Describes briefly and concisely the steps in the construction of the various types of asphaltic pavements and roads. Each type of construction is illustrated with photographs, and some of these photographs are supplemented by drawings and cross-sections.

Street Cleaning Machinery.—Elgin Sales Corporation, 501 Fifth Ave., New York City. 4-page circular describing and illustrating methods of using the street cleaning equipment made by this company.

Self-feeding Bucket Loader.—Barber-Greene Co., Aurora, Ill. 24-page booklet illustrating and describing methods of using this company's self-feeding bucket loader in handling concrete paving materials. Contains cost data on several jobs.

Engineers' Instruments and Supplies.—C. F. Pease Co., 841 North Franklin St., Chicago. 40-page catalog of field and office supplies. Prices and descriptions of each article are given and the [illegible] very fully illustrated.

Reinforcement for Concrete Pavements.—National Steel Fabric Co., First National Bank Bldg., Pittsburgh, Pa. Reprint of technical article by H. Eltinge Breed, Consulting Engineer, New York City, on "Reinforced vs. Plain Concrete Highways."

Road Making Machinery.—Stroud & Co., Omaha, Neb. 32-page catalog illustrating and describing the line of elevating graders, scrapers, wagons, truck bodies and other road building equipment manufactured by this company.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Volume LV. CHICAGO, ILL., FEBRUARY 9, 1921. Number 6.

Index of E. & C. Now Ready

The index for Vol. LIV covering the July-December issues of Engineering and Contracting is now ready for distribution. Subscribers desiring a copy should notify us at once. Those who received the indexes for the previous volumes have been listed and need not notify us again.

The Future of Construction Wages

Construction wages in many cities are 25 per cent lower than they were six months ago. It is our expectation that a similar reduction will occur in nearly all American cities this year. Coincidently there is occurring a marked increase in the efficiency of workmen. Thirty-two contractors, members of the Master Builders' Association of Atlanta, have agreed to put into effect a new wage schedule under which the hourly wages will be as follows:

	New.	Old.
Common labor	$0.30	$0.40-.50
Carpenters	.70	.85-.90
Plasterers and cement finishers	.90	1.25-1.40
Bricklayers	.90	1.25-1.40
Painters	.60	1.00

It is stated that the new scale is approximately 100 per cent higher than the pre-war scale, and that it is high enough to cover the increase in living expenses that has occurred in the last five years.

In estimating what rates of wages will probably prevail this year, sight should not be lost of the fact that the average wholesale price of farm products is now only about 50 per cent above the pre-war level. This is below the general average price level of other commodities, the general average being nearly 90 per cent above the pre-war level. With relatively low prices for farm products, it is certain that farmers will not pay their employes as high wages as they paid last year. This will have its effect upon the average wage of common laborers in all country districts. On the other hand, the wages of skilled workers in the cities will probably not decline as rapidly or as far as unskilled wages in the country.

It is our opinion that we shall see higher construction wages in 1922 than in 1921. The revival of construction activity that will occur this year will probably gain such momentum as to create a greater demand for construction workers a year hence. This was the history after the Civil War, when construction work once got into full swing. Then came seven years of great construction activity during which the average price of construction materials remained practically constant, while wages increased.

The Underpayment of Technical Men by the Government

There are about 10,000 technical and scientific government employes in Washington, D. C. Mr. R. S. McBride, in a recent issue of Chemical and Metallurgical Engineering, states that, during the years 1916 to 1919, 1,314 of these employes left the government service in six bureaus, namely, the Geological Survey, Patent Office, Bureau of Mines, Forestry Service, Bureau of Markets, and Bureau of Standards. Questionnaires sent to those men brought 1,173 answers, from which it is shown that their average salary at the time of leaving was $1,806, and that after leaving it was $2,761. Of these men 609 received an average of $1,456 the first year with the government, and, after nearly five years service resigned when their salary averaged $1,987, to accept positions at a salary of $2,880. Three years and eight months later the salaries of these same men averaged $4,458. Commenting on these data Mr. McBride says:

> The fact that approximately four times the increase per year has been found after leaving the Government service as in the service is very significant. Because of the higher actual salary the percentage increase is only approximately double outside as inside. At the rate of increase normal in the Government it would require more than 20 years to reach the average outside salary level reported, whereas this same increase is accomplished in approximately eight years under commercial conditions.

Engineers not in government employ are apt to be indifferent to facts like those just cited, but a little consideration of the matter should serve to convince us all that it is our duty to assist in securing adequate salaries for all technical men in public service. To begin with, it is very poor advertising to have it generally known that technical engineers in public service receive an average income that is less than that of locomotive "engineers". The public usually judges the relative importance of men by their incomes. In the second place inadequate payment for technical services will ultimately drive most of the ambitious technicians out of government employ. This would be a public calamity of the first order.

Now that average wholesale commodity prices have declined 30 per cent from the peak of last May, there are many men ignorant enough to predict a rapid return to the pre-war level. It devolves upon those of us who know better to do all in our power to convince law makers and public officials that commodity prices will remain far above the pre-war level for many years, hence, that salaries should be raised proportionately. It is probable—almost to a certainty—that the new plateau of prices will be 60 to 70 per cent above the pre-war level. If so, the average technician in government employ should receive an increase of fully $1,000 annually. This would add inappreciably to Uncle Sam's payroll, but it would insure his holding thousands of competent scientific men who will otherwise surely leave his service.

Engineers and Contractors Confer

At the second annual conference of the Associated Contractors of America, during the latter part of January, six papers were read by men who are not contractors. An architect, an official of a labor union, and four civil engineers presented their points of view. Three of the engineers discussed specifications.

Fifteen years ago Engineering and Contracting began urging the plan of having engineering and contracting societies meet jointly to confer about common interests, such as contracts. Although no joint session of this sort has yet occurred, it is encouraging to observe the growing frequency with which individual members of engineering and contracting societies meet for conferences. Not long ago the California State Highway Commission and a committee of the Associated General Contractors arranged to have members of the A. G. C. present at the monthly meetings of the division engineers of the Highway Commission. Any complaints of members of the A. G. C. are to be presented at these monthly meetings.

The day is not distant, we hope, when contractors and engineers throughout the country will confer regularly and frequently.

Campaign to Restore Confidence

Published propaganda against profiteering was the main factor in starting the present business depression. When almost every daily paper was inveighing against the profiteer a buyers' strike was easily brought about. It was foolish propaganda, but it was effective, for the American public is easily led when practically all editors spout the same advice.

Contrasting the editorials of last February with those of today, it is significant that the chorus of advice is now in quite a different key. Now the public is being told that it is a social duty to buy as liberally as possible, in order to restore prosperity. We may expect to hear this chorus grow louder and louder, until it drowns every note of despair. Before summer arrives it will be the all but universal opinion that prosperity depends upon buying rather than upon refusing to buy. This is sane propaganda which will soon counteract the effects of the insane propaganda of a year ago. Courage, be it remembered, is as contagious as cowardice.

Engineers for Water Resources Branch of U. S. Geological Survey.—The U. S. Civil Service Commission has announced open competition examinations for the positions of engineer, assistant engineer and junior engineer. Entrance salary for engineer is $2,400; for assistant engineer, $1,800 to $2,340 a year; junior engineer, $1,440 to $1,700 a year. Graduation from an engineering course of a college or university of recognized standing is a prerequisite for consideration for these positions, except that for the position of junior engineer applications will be accepted from senior students.

What Is Wrought Pipe?

One would naturally suppose that when he specified "wrought-iron pipe" he would get, or at least be entitled to, pipe made of wrought iron. Steel pipe is commonly known and billed, however, as "wrought pipe," and jobbers and contractors are prone to install steel pipe instead of the more expensive wrought-iron material when the latter is specified, and are able to get away with it in court on the plea that "wrought-iron pipe" is a trade term meaning either wrought-iron or steel pipe as distinguished from cast-iron pipe.

In order that there may be on record an authoritative utterance upon this subject, the Executive Committee and Advisory Board of the National Pipe and Supplies Association has forcibly called attention to the distinction made by the American Society for Testing Materials in the following resolution:

> Whereas, The distributors of pipe for many years used terms to designate the various types and makes of pipe that have not been duly descriptive of same; and,
>
> Whereas, It is the desire of this association to co-operate in every way with the manufacturers in the development of trade practices and customs of accepted merit, and which will be fair and intelligible to the manufacturer, distributor and public alike,
>
> It Is Hereby Resolved, By the officers and members of the Executive Committee and Advisory Board of the National Pipe and Supplies Association in their fall meeting, held in New York City on Thursday, Nov. 11, that it is their judgment that the terms employed by the American Society for Testing Materials in differentiating between Iron and Steel Pipe—namely: (a) Welded Wrought-Iron Pipe; (b) Welded Steel Pipe—should be accepted and adhered to by the distributors of both iron and steel pipe, this being in the interest of the manufacturers of the pipe, those who distribute it and those who use it, each being entitled to know clearly and without doubt the make and quality of the pipe involved in the transaction.

This means, if it means anything, that welded pipe is pipe that is welded no matter what it is made of; that welded steel pipe is pipe that is made by welding steel; that welded wrought-iron pipe is pipe that is made of wrought iron by the welding process and that "wrought-iron pipe" is pipe that is made of wrought iron whatever the process of manufacture.—Editorial in Power.

Engineering Reports—Partisan and Impartial

"Ideal engineering reports are in effect miniature court decisions. The evidence is first arranged, the arguments are presented, and finally an engineering judgment is rendered." Thus one of the well-known consulting engineers of Chicago writes in his contribution to a discussion of the function and make-up of engineering consultants' reports. The same communication goes on to discuss how material should be treated by the engineer who makes the report, giving splendid suggestions on many points. But one point is not raised in this discussion—as to the attitude of the executive or board of directors for whom the report is prepared.

Facts are often uncomfortable things and judicially minded decisions and advice sometimes are disappointing. Nevertheless, when a consultant is engaged great pains should be taken that he is given full opportunity to get the facts and render to the best of his ability an absolutely impartial report or finding. To insure this is a part of the responsibility of the executive or board for whom the report is being prepared.

An outside investigator or adviser, unless unusually tactful or of unusual fame and ability, is likely to be received in anything but a friendly way by the operating staff whose work is under scrutiny. The lot of a consultant who is to advise as between two recommendations of the staff is particularly unhappy because of these factors. However, much of the possible good from expert assistance is lost unless some executive means be found to give the whole truth as a basis for recommendations. The executive should not be satisfied with a report based upon an investigation which has been in any way hampered to prevent such judicial consideration of all important pertinent factors.

There are, of course, many occasions upon which a consultant is engaged to assist in controversial matters as between a company and the authorities, or a company and some other commercial agency with which it happens to have legal or commercial difficulties. A report prepared by a consultant or with his assistance for public use and partisan purposes is, of course, proper in such circumstances. The consultant does not expect to emphasize both sides of the question, but will limit himself to the presentation of the points favorable to his client, which he will set forth honestly and as effectively as circumstances permit. For such work the consultant becomes in effect an advocate and takes on himself all of the responsibility and privileges of the attorney advocate, except that he usually limits his effort to the technical field.

This same attitude cannot successfully be assumed in reports prepared for the assistance of executive officers. For such latter purposes a discussion of both sides of any case, setting forth the strong points for and against the decision finally reached, is most satisfactory. The executive is entitled to know the evidence on both sides. Indeed, the final recommendation of the expert is strengthened by a frank presentation of the best arguments which may be advanced against his findings, even though the final recommendation be a definite judgment. The executive who receives such report is fortunate, for he can feel sure that his adviser has taken into account both sides of the question and has not simply undertaken to present convincing arguments in support of preconceived ideas.—Editorial in Chemical and Metallurgical Engineering.

Water Department Pays Taxes, and Charges All City Departments for Water Used by Them

The city of Holyoke, Mass., is probably the only municipality in the country which collects payments from schools and other city departments for the water used by them. On the other hand the Water Department pays taxes to the city treasury. These payments are made under a law enacted in 1901, the provisions of which include the following:

> Section 2 The said Board of Water Commissioners is hereby authorized and directed to pay over to the treasurer of the said city in each year, on or before the 1st of November, from its net earnings, a percentage upon the total cost of the construction of said water works, as estimated in the annual reports of the said commissioners, which shall be the same as the percentage of taxation established for city, county and state taxes in the city of Holyoke in that year. The treasurer is hereby authorized and directed to collect the said sum and pay over the same to the commissioners of the sinking fund for the payment of municipal bonds. In case the net earnings do not equal the said percentage, the wole net earnings shall be paid over as aforesaid. The amount so paid or collected shall be used toward the payment of municipal bonds, other than water bonds.
>
> Section 3—The Board of Water Commissioners is hereby authorized and directed to collect payment from all municipal departments of the city of Holyoke except the Fire Department, for the water used by them, at the same rate which is paid by other consumers.
>
> Section 4—The Board of Water Commissioners is also hereby authorized and directed to collect from the Fire Department an annual rental, not exceeding eight dollars ($8.00), for each public hydrant. This rental shall include the cost of all water used by the Fire Department for fire or other purposes, including the cost of furnishing and maintaining hydrants.

According to a paper presented last September before the New England Waterworks Association by Mr. P. J. Lucey, engineer of the Holyoke Water Department the total of all payments made by the water department to the city treasurer under the above provisions had been $422,556.26, and the amount received by the water department from the other municipal departments had been $215,863.28, making the net cash contribution the water-takers have made for the benefit of the general taxpayer, $206,692.98.

Convention of American Concrete Institute.—The American Concrete Institute will hold a convention Feb. 14, 15 and 16 at the Auditorium Hotel, Chicago. The convention will include sessions of the liveliest practical interest to contractors; sessions of interest to designers of concrete structures looking to economy and integrity of the work; a session for concrete products manufacturers, including subjects of the utmost importance in the development of concrete building units and concrete pipe; a session for concrete road builders taking up chiefly subjects bearing upon the working problems on the job. Harvey Whipple, 314 New Telegraph Bldg., Detroit, Mich., is Secretary of the Institute.

General Policies of Engineering Division of Pennsylvania Department of Health

During the past summer months the engineering division of the Pennsylvania Department of Health has been reorganized into sections on housing, investigation of industrial wastes, pollution, restaurant hygiene inspection, rural sanitation, waterworks and sewerage, and chemical and bacteriological laboratory. The general policies of the division under this plan were outlined as follows by Mr. C. A. Emerson, Jr., Chief Engineer, in a recent issue of Public Health Notes: The state has been divided into eight districts, each district in charge of an engineer with one or more assistant engineers. Under general direction of the chief of the waterworks and sewerage section, the district engineer has responsible charge of waterworks and sewerage applications, examination of plans, field investigations, and reports thereon and on the operation of waterworks and sewerage systems. After careful investigation of the present use and conditions of the waters of the state in his district, the district engineer will recommend to the chief engineer policies for the use of various streams or parts of streams in his district as regards water supply and sewage disposal, stating the degree of purification for water and treatment of sewage required. When approved by the chief engineer and directed by the chief of the waterworks and sewerage section, the district engineer will have investigations made for the rural sanitation and housing sections and will make recommendations for the correction of insanitary conditions involving engineering in his district. When approved by the chief engineer, the district engineer, under the general direction of the chief of the waterworks and sewerage section, will co-operate with the county medical director or the medical division in typhoid epidemics. The district engineer will limit his activities to engineering matters, such as water supplies, sewerage, excreta disposal, milk supplies, etc., leaving all medical matters, unless otherwise specifically ordered, under the jurisdiction of the medical officers.

The rural sanitation section has one or more district inspectors in each district, whose duties are as follows:

(a) In second-class townships: Inspect and secure abatement of public health nuisances requiring knowledge beyond the ability of the department health officers.

(b) In municipalities: Inspect and secure abatement of public health nuisances in cases where the local board of health fails to secure abatement and where the conditions are not sufficiently acute for the state department of health to take over the functions of the local board of health.

(c) Assist in instruction and guidance of local health committees and local boards of health.

(d) Report on the efficiency of department health officers.

(e) Inspect and secure abatement of pollutions on watersheds of streams used for public water supplies, and train health officers and water company representatives in doing such work.

(f) Serve notices, secure evidence, etc., incidental to prosecutions in cases of public health nuisances and stream pollutions.

(g) Sample private water supplies as ordered.

(h) Such other duties as may be assigned by the chief of the rural sanitation section.

When temporarily assigned by the chief of the rural sanitation section to the waterworks and sewerage section, district inspectors will perform the following work under the direction of the district engineer or his representative:

(a) Make field investigations to determine compliance with provisions of waterworks and sewerage permits and decrees.

(b) Sample public water supplies.

(c) Supervise the installation and maintenance of emergency waterworks disinfection apparatus.

(d) Post notices.

(e) Seal by-pass connections of public water supplies.

(f) Take "census" during typhoid fever epidemics.

(g) Inspect the production, handling, and distribution of milk supplies during typhoid epidemic investigations.

(h) Such other duties as may be assigned by the district engineer.

Simple System of Sewage Disposal for Isolated Dwellings

A simple and inexpensive method of sewage disposal for the isolated dwelling or the small group of houses supplied with running water and provided with toilet, sink and bath fixtures, is described by Mr. H. R. Crohurst, Associate Sanitary Engineer, U. S. Public Health Service, in a recent issue of Public Health Notes. Mr. Crohurst's article is based on material obtained from a bulletin, "Free Flowing, Tight Sifter Tanks," by Mr. Robert Fletcher, published by the State Board of Health of New Hampshire; on information obtained from Mr. D. M. Tefft, health officer of Sugar Hill, N. H., who has had 11 years' experience in the construction and operation of tanks of the type described; and on an inspection of tanks in operation at Claremont, N. H., and Sugar Hill, N. H. The matter following is abstracted from the article.

In 1910, or about that time, the State Board of Health of New Hampshire was called upon to devise a practicable and sanitary method of sewage disposal for single residences, summer cottages, and hotels. As a result there has been developed by Robert Fletcher, D. Sc., C. E., president of the State Board of Health, the so-called "Free-flowing, tight, sewage tank," which, during the past 10 years, has been in successful operation, under varying conditions, in several hundred locations in that State.

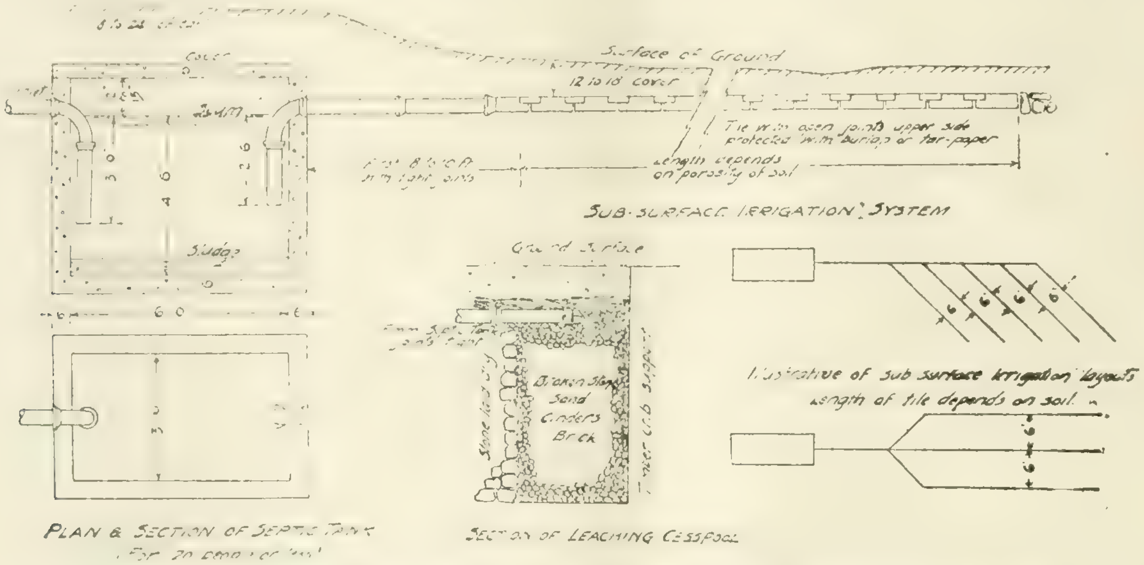

Surface of Ground
12 to 18 cover
Cover
Inlet
Outlet
Sludge
6 0
Tile with open joints upper side protected with burlap or tar-paper
Length depends on porosity of soil
SUB-SURFACE IRRIGATION SYSTEM
Ground Surface
Broken Stone
Sand
Cinders
Brick
Stone laid dry
PLAN & SECTION OF SEPTIC TANK
SECTION OF LEACHING CESSPOOL
Illustrative of sub surface irrigation layouts
Length of tile depends on soil

Fig. 1—Details of Septic Tank and Various Methods of Effluent Disposal in a Porous Soil.

The design, as now recommended by the State board, consists of a rectangular tank, built of concrete, without baffles, with a relatively tight-fitting cover and without ventilation. A space of from 12 to 15 in. is provided between the under side of the cover and the surface of the sewage. The cover is made to fit as tightly as possible, in order that the gas given off during the septic action may develop a slight pressure in the dead space above the sewage and serve to exclude outside air. The inlet and outlet pipes of the tank are provided with elbows, which turn downward into the sewage and end well below the surface. Experience in New Hampshire has shown that a capacity of 4 cu. ft. (30 gal.) should be allowed for each person contributing to the tank.

The smallest tank recommended is 6 ft. long, 3½ ft. wide, and has a depth of sewage of 4½ ft. Such a tank has a capacity of about 94 cu. ft. (excluding dead space above sewage) and would effectively serve 20 persons. It is not deemed advisable to build a tank smaller than this. For larger installations the following sizes are recommended:

[illegible]	Length. Feet.	Width. Feet.	Depth of Sewage. Feet.
[illegible] persons	[illegible]	[illegible]	4.5
[illegible]	[illegible]	4.5	5
[illegible]	[illegible]	5	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

The tanks should be located in the yard, as near the house as practicable, and should be buried in the ground and have a covering of 12 to 18 in. of soil. The temperature of house sewage combined with the heat generated by septic action helps to prevent freezing in winter.

As the effluent of a septic tank is only partially purified sewage containing organic matter which is potentially capable of causing objectionable conditions if not properly disposed of, and as it contains at all times many bacteria, among which may be those capable of causing disease, the proper disposal of septic-tank effluent is a matter of very great importance.

For the small installation subsurface irrigation seems to offer the easiest means of disposing of the tank effluent. Where the soil is porous and the seepage rapid, the effluent may be discharged into a leaching cesspool, blind drain, or subsurface tile system. The details of construction of the septic tank and various methods of effluent disposal, in a porous soil, are shown in Fig. 1.

Where the soil is tight and does not allow the rapid passage of liquids, a filter trench may be required. This is constructed by laying two lines of tile, one above the other, in a trench or series of trenches, with an artificial filtering medium between the upper and lower line of tile. The tank effluent is distributed by the upper line of tile, trickles through the filtering material, and is collected in the lower line of tile, from which it may be discharged into an open ditch or into a watercourse. Where a filter trench is used for secondary treatment, there is usually, and always should be, provided a dosing chamber containing an automatic siphon, which collects the tank effluent and discharges it into the trench in a single large flush, thus utilizing the entire volume of the bed. A constant trickle from the tank overdoses a small portion of the trench. For larger installations where secondary treatment consists of sand filters, contact beds, or trickling filters, a dosing tank and automatic siphon are always needed. The construction details for a septic tank, dosing chamber with automatic siphon, and filter trench, are shown in Fig. 2.

The sewer line from the house to the septic tank should not be less than 4 in. in diameter, preferably 6 in., should have tight joints, and should have a fall of about 1 ft. in 100 ft. The tank should be made of concrete, carefully constructed, and made watertight; and for large installations, reinforcing should be provided. The dosing chamber should have a capacity of about 80 gal. and should be equipped with a 3-in. automatic siphon. The tile lines should be 4 or 6 in. in diameter, laid with open joints, the upper portions of the opening being covered with tar paper, burlap, or old linoleum to prevent soil from entering the line. The irrigation tiles should have a fall of about 2 or 3 in. per hundred feet. A mat of hay or straw laid over the tile lines and filter material serves to hold the back fill and prevent mud from entering when the ground is moist after rains. The first 10 to 15 ft. between the tank and the irrigation system, or between the dosing chamber and the irrigation system, should have tight joints to prevent the effluent from soaking into the ground in the immediate vicinity of the tank.

The length of tile lines in the disposal system will depend upon the character of the soil in which the tile is laid. In a coarse sandy soil, 20 ft. per person using the tank [illegible] sufficient; whereas in a tight sandy clay soil 100 ft. or more per person may be required.. Where a dosing chamber and siphon are used, the size of dose determines the length of tile lines required. The tile lines should have a capacity equal to or greater than the capacity of the dosing chamber. Assuming the capacity of the dosing chamber to be 80 gal., there should be provided about 125 ft. of 4-in. tile, or about 60 ft. of 6-in., to receive at once the entire flush when the dosing tank is emptied

In outlining plans for the construction of septic-tank systems, it is the rule to recommend the installation of a grease trap between the kitchen fixtures and the septic tank, to remove grease from the sewage. In the New Hampshire system no grease trap is provided, and the tanks appear not to be affected by the presence of the grease in the sewage. To prevent trouble at times, it is advisable, however, to remove as much grease as possible from the kitchen wastes and dispose of it by some other method. All excess water which can be excluded conveniently should be excluded from the tank, as continuous flow, without quiescent periods, disturbs septic action.

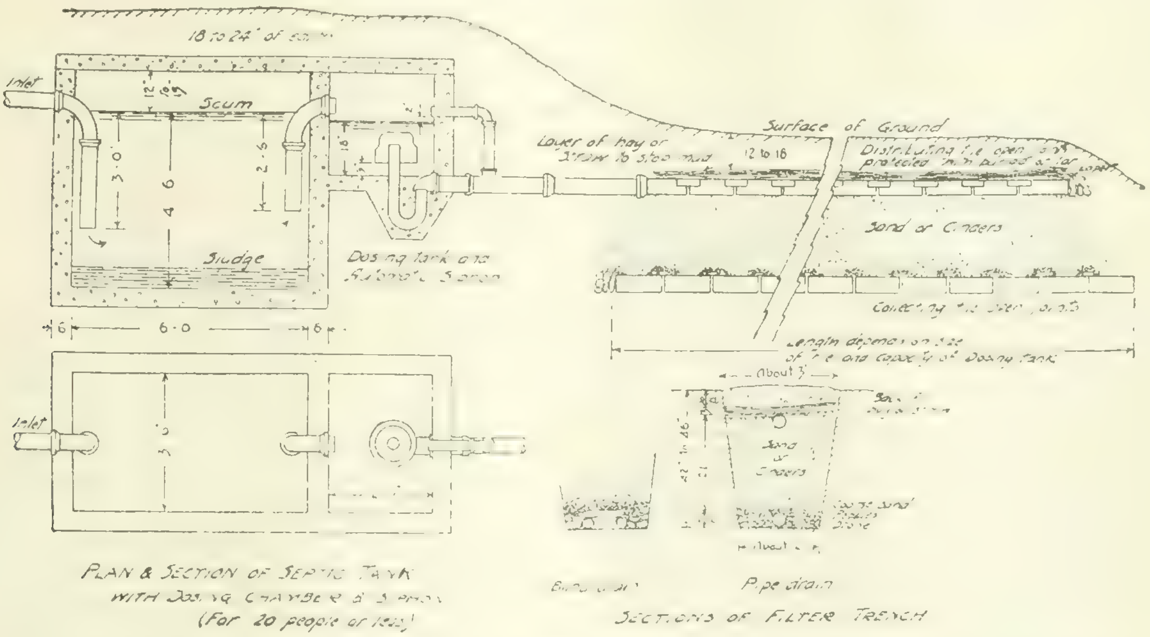

18 to 24" of earth
Inlet
12
Scum
3·0
4·6
2·6
18
Sludge
Dosing tank and Automatic Siphon
Layer of hay or straw to stop mud
12 to 16
Surface of Ground
Sand or Cinders
Collecting tile
Length depends on size of tile and capacity of Dosing tank
6
6·0
6
Inlet
3·6
About 3'
42" to 46"
Sand or Cinders
Pipe drain
PLAN & SECTION OF SEPTIC TANK
WITH DOSING CHAMBER & SIPHON
(For 20 people or less)
SECTIONS OF FILTER TRENCH

Fig. 2—Construction Details for Septic Tank, Dosing Chamber With Automatic Siphon and Filter Trench.

The oldest New Hampshire tanks have now been in operation and successfully disposing of combined household wastes for a period of 11 years, and, so far, have never required cleaning. The effluent is relatively clear and odorless and in some instances has been disposed of by irrigation over the surface of the ground without offense; but this method from a sanitary standpoint is not recommended.

For the single residence or small group of homes, where a sewerage system is not practicable, it appears that a sewage-disposal system of this type offers a reasonably cheap and efficient method of disposal and requires a minimum amount of suspension after installation. The successful operation of these tanks in New Hampshire suggests that similar results could be obtained in other sections of the country having comparable climatic conditions. The successful operation of a system of this type in sections having summer temperatures much higher and of longer duration cannot be definitely stated before a study of installation under such conditions has been made; but it appears probable that the system will give results in the southern sections of the United States similar to those given by it in New Hampshire.

City Manager Plan for Vermont Municipality.—By a vote of 318 to 287, St. Albans, Vt., at a special meeting Feb. 1, voted in favor of an amendment to the city charter providing for the city manager plan of government. If the new amendment to the charter is passed by both houses of the Vermont Legislature it will go into effect after the 1921 March meeting. B. M. Hopkins is City Clerk.

"Value" vs. "Investment" as a Basis for Utility Service Rates

The intellectual independence required of the engineer makes him little prone to the blind acceptance of dicta, from even so high an authority as the United States Supreme Court; and though his actions must be guided by the decisions, his personal opinions, if in disagreement, will find continued expression until the question involved is settled reasonably, whether for or against him, and however long the time required.

"Cost of Reproduction Less Depreciation Plus Going Value," although apparently quite definitely accepted by the courts as constituting "Fair Value," and therefore the proper rate base, finds much disapproval among engineers and economists. An associated subject of discussion is that of the relation between fair rate of return, current interest rate, and charging costs of construction. All of these matters are discussed by Prof. William G. Raymond in a paper bearing the title of this article and read recently before the Iowa Section of the American Water Works Association.

Complete agreement of opinion between individuals on questions of the character and complexities of these is the exception rather than the rule; but Prof. Raymond's discussion is not less valuable because it will not please everybody, nor perhaps wholly please anybody, who reads it. The first part of the paper deals with economic principles and matters of accounting principle and practice which for the most part have been previously treated in the columns of Engineering and Contracting and are therefore not now quoted. The latter part dealing with the rate base and interest rate follows:

Value Really Dependent Upon Earnings.—It is not value that determines return—nor can it ever be—it is return that determines value—and this is not a quibble over words. The Supreme Court of the United States has said that a public utility owner is entitled to a fair return on the fair value of the property that he devotes to the service of the public. This is the law just now. To the layman it seems like good law, but it is very difficult of interpretation and administration. Interpretation and administration would be much simpler and more satisfactory if the court had never formulated the law in the precise words that it has used, but had laid stress on the other law that it has established, namely: that the utility is entitled to charge for its service only so much as the service may be reasonably worth. The two laws must be in harmony or both cannot be law. If in interpreting and administering the law, fair rates are based on worth of service, and this in turn is based on cost to the community served to serve itself with the same plant as the one that may be under consideration and with reasonable efficiency, there will be little ambiguity—little difference over what to include in cost of reproduction little difference of [illegible] value a term that never should have been [illegible] about depreciation. The only [illegible] trouble would be the fair rate of profit to be earned—and this is purely a judicial matter. Most of the [illegible] would have vanished, because when a community is serving itself with a physical plant, it is investment, not cost of reproduction that is considered. And investment does not change from day to day, or year to year, with changes in the cost of the items entering into the construction of the service plant.

Concurrent Changes in Costs and Interest Rates.—Just now prices of all consumable commodities are high. Interest rates are high. Economists tell us that the causes are not the same. But the effect is the same—and all service of every kind is just now worth more than formerly because it costs more dollars, and because he who renders service must have more dollars for his living in order to have the same living as formerly, and because the use of the service in industry brings more dollars to the user than formerly.

If I make my living by the rental of houses that I own, I must increase my rental rate because all of my expenses have increased in dollars. My investment remains as it was in 100 ct. dollars, but I must earn a higher rate of return on it. In fairness I am not entitled to the higher rate on an arbitrarily increased value assigned to my investment based on 50 ct. dollars. I can't increase the value of my investment by the amount of changes in the purchasing power of the dollar and charge a rate of return on that increased value which also reflects the change in the value of the dollar. It makes no difference whether the causes of high prices and high interest are the same or not. My investment is only half what it was in purchasing power and I must have twice the rate of return on this half to provide my living expenses; to make me the same living that I enjoyed before the war. In fairness I am entitled to no more from the source named.

What must happen is that I must have as many bushels of potatoes, if potatoes are my diet, for my rentals as I had before money became cheap. If potatoes now cost twice as much as they did, I must have either twice the rate of return on my investment or the same rate of return on an arbitrarily increased investment value. But I do not need both twice the investment value and twice the old rate of return on this inflated value. It is useless to say in opposing this statement that one's needs do not govern his legitimate profits in business. It is impossible to treat a public utility property just as if it were a freely competitive unregulated enterprise. And it must not be forgotten that charging unreasonable profits in any business connected with the necessities of life is contrary to public policy.

On a new investment made now, I must have the high rate of return because these dollars that I am now investing will buy only half as many potatoes, half as much house, half as much useful property, as dollars formerly invested and hence I must have twice the rate of return even on these high investment costs in order to be as well fed as I was before the war.

Utilities in these days are pleading for values based on reproduction costs and are also showing the increased rates charged for borrowed money in an attempt to get higher "fair returns" than formerly and on higher values than the real investment. A recent New Jersey Supreme Court decision seems to be a defense of such pleading. But it is believed to be wrong.

Utility Property Not Now Saleable.—In support of the pleading the following argument is made: If I own a water works property and wish to sell it and reinvest my money in another water works property just like the one I own I must get the present day cost of the new property out of the old one or I shall lose something. And when I reinvest this cost in the new property I must have the present day rate of return on it. This is not true. I have just the same value investment that I had before. Neither can it be said that I can sell my old works at new cost of reproduction price and invest the proceeds otherwise at high rates. Has it occurred to the persons offering this argument that there are no utility properties being sold at present day reproduction costs? In the face of a soon to be falling market one would be foolish indeed to pay present reproduction prices for utility properties. Men who make such investments are not foolish to this extent. Only necessary additions are being made to existing properties, and on the cost of these necessary additions the going rate of return should be realized. No permanent investment or investment in a permanent enterprise of long standing is worth on the market today a sum based on or approximating present day cost of reproduction unless its earnings have warranted such worth.

Effect of Price Changes on Different Classes of Investments.—No owner of bonds, mortgages, or stock of utility enterprises, nor any depositor in a savings bank, finds any more dollars in his hand, due to a change in the value of the dollar, when selling his bonds or stock or receiving back his own from a mortgagor or savings bank than he put into those investments before the war, except as he may have purchased at a discount. Utility securities do not reflect any such increase in value as the difference between pre-war and post-war prices. Quite the contrary is the more common experience even in those cases where reasonable advances in rates have been made. In general it is true that bank stocks, insurance company stocks and other like stable securities of regulated enterprises show no advance commensurate with the change in the value of the dollar.

Neither will he who loans today on a mortgage, or buys bonds of a utility, receive less dollars than he now loans, when after some years his mortgage loan is paid and his bonds mature. The value of the dollar will have increased but the lender will receive just so many dollars as he loaned, no less and, barring the effect of discount, no more.

It is true that investments in utility properties are not exactly like loans on mortgages, but neither are they like investments made in unregulated, freely competitive businesses, free to earn all that their managers can make them earn. Utility properties have both privileges and restrictions not enjoyed or suffered by unregulated, freely competitive properties, and if anything were needed to demonstrate the fact that the cost of reproduction new less depreciation is not the value of a public utility property, or indeed, any regulated property, the fact that the securities of these properties in no wise reflect the change in the value of the dollar ought to be sufficient.

Indeed, the securities of very few incorporated industries, regulated or unregulated, reflect the change in the value of the dollar. The stocks of a few industries that have been able to make large profits during the war period did advance in value, many of them even much more than the change in the value of the dollar would indicate, but always because of a change in their earnings, never because of a change in the cost of reproducing the physical property that was the instrument with which the management conducted its enterprise. It ought to be clear that the value of a going property is not what it would cost to reproduce that property. Its value is what it can earn at fair charges capitalized at a determined going rate for money providing its earnings are secure for the future.

What Did the Court Mean in Smythe vs. Ames?—It is clear that the court did not mean value when it said value in that old Smythe vs. Ames decision. It is clear from the interpretation given by later decisions that it did not mean the sum necessary to create the property new as of the date of valuation, less existing depreciation, because it has definitely excluded from allowable costs of reproduction the costs of certain items that would of necessity be a part of a new construction at the time of valuation—notably the removal and replacing of pavement over underground construction in those places where no pavements existed at the time the underground construction was placed. Apparently what it did mean, if the later decisions are to be taken as interpretations, was the present day (present day meaning the date of valuation) cost of doing the things that were done to create the property, but by present day methods and with presently existing facilties. Always it is cost not value that is found.

Cost or Value?—Even the item of "going value" is by some engineers being reduced to a quantity said to represent the cost of producing the business of the property, and this definition has been most often apparently in the minds of the courts when writing opinions, although the first decision that included the item did not suggest the idea of cost at all. Engineers not liking judgment guesses and trying always to reduce all procedure to definite formulas, have suggested various ways of finding "going value"—and while the final deliverance of the court is still a judgment guess it is based upon engineers' testimony which is most often based on an estimate of the cost of developing the business. Again it is cost of the property used in the service of the public that is assumed to be meant by that word value in the historic reference case. Present day costs, then, of doing the things that were done to create the property, both the cost of the physical plant used by the management in producing service, and the cost of developing the working organization, and, curiously enough, the cost of developing a properly remunerative business, not the business enjoyed by the property at the time of valuation but the business that it ought to enjoy pre-determined by the engineer before the court has acted, as a step precedent to his estimate of going value, are assumed to be equivalent to value. Very curious procedure—, this.

With respect to the physical plant at least, the generally accepted method means, so far as differences between 1914 and 1920 are concerned, during which few years there was little change in method or facilities, original cost to date appreciated to allow for the cheapened dollar. And original cost to date is investment.

Now, while because of the scarcity of houses and machinery, as compared with this demand, a good many buildings and some machines are changing hands these days on a basis of new prices, land has shown no such extreme advance, except land that has produced greater earnings than heretofore. And as has been noted already, utility properties are not changing hands on any basis at all and certainly will not change hands on a basis of new prices; nor will any new utility properties be built by private enterprise so long as the clouds of reproduction cost value and falling prices are darkening the view of the future. What must be spent on existing plants will be spent if money can be found, but no more.

Does not it seem to be clear, therefore, that present day reproduction costs of old properties are not their values, nor even the proper bases for estimating fair return at present day high rates?

And even in normal times, if such there be, when market prices are rising and falling alternately, is it the custom of any business to vary its book investment, on which it figures returns, from year to year up and down with the change in the prices of the building materials and labor used in the construction of the plant which it uses in its activities? Not so. Nor should it be so. For practical purposes the investment in a business plant does not vary from year to year with variation in the cost of the items that are included in its construction, how ever much it may do so in theory. After some years of more or less steady change in value of real estate, that part of the property may be written up or down as the case may be, but the wearing items of machinery are carried at what they cost until they are worn out or disposed of in some other way. But earnings are made to vary so far as possible with the needs of the times.

So would it seem to be proper to do with utility properties. Regulation providing for fair return on the investment, as that is considered in purely private ventures, the rate varying with the needs of the times, should never be deemed to result in the taking of private property without due process of law nor without just compensation.

If we would just be fair with ourselves, recognize investment rather than cost of reproduction, misnamed value, as the basis for earnings, make it possible for a utility company to earn such a return as will command capital, varying the rate of return with the necessity of the times; deal with the utility fairly, and require fair dealing from it, we would have less troublesome litigation, less occasion or desire on the part of the utility to use sharp practice to secure fair return for its service, better service and greater contentment and comfort for the public and its utility servants.

Fair Return and the Market Rate for Money.—A short time ago, in a paper not yet published, an effort was made to develop a logical method for finding fair return rate. It was concluded that from once and a third to once and two-thirds the market rate for money used in the particular industry in question is the fair rate of return. This is based on the preliminary conclusion also developed in the discussion that it is most advantageous from the public standpoint that from two-thirds to three-fourths of the money invested in a utility enterprise shall be borrowed. This proportion of borrowed money reduces the return on account of risk to a minimum. It is reasoned that net earnings of twice the fixed charges must be shown to induce capital to venture as loans on mortgage; that is, to buy bonds. If the reasoning is correct, there should be net returns of twice the market rate on from two-thirds to three-fourths of the investment. This means from once and one-third to once and one-half the market rate on the whole investment.

It is believed that if utilities are allowed such return rates on their investments, full operating costs, and depreciation allowances, based on investment, there will be little further litigation, the utilities will be satisfied, and the public should be satisfied because it will be paying no more than a fair return on the investment used in its service. There will be no more discussions of "going value" nor arguments as to what shall be included in cost of reproduction. Costly work for lawyers and engineering experts will be minimized. Peace will reign whether prices go up or down.

Port Requirements

An interesting discussion of the above subject was held at the December meeting of the New York Section of the American Society of Civil Engineers. Some of the more important points brought out are summarized as follows in the January Proceedings of the American Society of Civil Engineers:

Mr. Cresson sounded a warning against the acceptance of additional cargo-handling machinery as a cure-all for port troubles, although he quite appreciated the value of such machinery when intelligently adapted to economic requirements. He indicated the intimate relation between the port problem and that involved in the handling and distribution of the foodstuffs for New York City, and he considers a study of the marketing situation as an important phase of the Port investigation. He brought out, also, the lack of warehouse and storage accommodations, and the resulting practice of using carriers to perform warehousing functions.

Mr. Webster outlined the organization of the Port of Philadelphia and explained the method by which the rail carriers co-ordinate their service to the port. He described the pier layout and plan in operation at Philadelphia and expressed his judgment that in ports where railroads lead to a river front, it is desirable and economical that wide piers be constructed and that the waterfront be well co-ordinated with the railroads.

Mr. Meigs considered the principal difficulty of the harbor problem to be the fact that New York City is on the wrong side of the harbor. He asserted that New York "is certainly not an economical port" but is, in fact, probably "the most expensive port in the country if we consider the average cost of the entire freight movement in it." He considers the crux of the economic difficulty to be in the present rate structure, which includes free delivery in New York, and of which any sudden dislocation would play havoc with established agencies and facilities. He touched on the possibility of drastic action in this matter on the part of the Interstate Commerce Commission.

Mr. Goodrich pointed out that the design of the port need not be based on the requirements of the few very large ships, as most cargo is handled in smaller bottoms. He contended that sometimes the payment of demurrage is cheaper than the investment of large sums in pier construction, and showed that the narrow pier is the more advantageous type when lighterage is an important consideration. He answered the criticisms that had been offered as to the cost of shipping through New York by citing cases in which Philadelphia shippers had sent goods by truck to New York for shipment there.

Mr. Mantell emphasized the wastefulness of the port and urged as the principal elements of the remedy: (1) Storage in New Jersey, and a belt line railroad; (2), store door delivery; (3) Hudson River Bridge; (4) Co-ordination and electrification of New Jersey suburban railroad lines. He stated his belief that the new vehicular tunnel will be overloaded within a year of its completion.

Ducks Keep Moss from Irrigation Lateral.—Mr. J. A. Latimer of Delta, Colo., a water user on the Uncompahgre Project of the U. S. Reclamation Service, writes as follows in the January Reclamation Record:

"About 18 years ago it was very sultry and hot and the moss grew worse that year than others. I had 89 ducks; they fed themselves and kept ½ mile of ditch entirely free from moss. I never had any trouble, while others could hardly keep water running."

Lowering Concrete Well Pits by Caisson Method

By FREELAND MANSFIELD

[illegible]

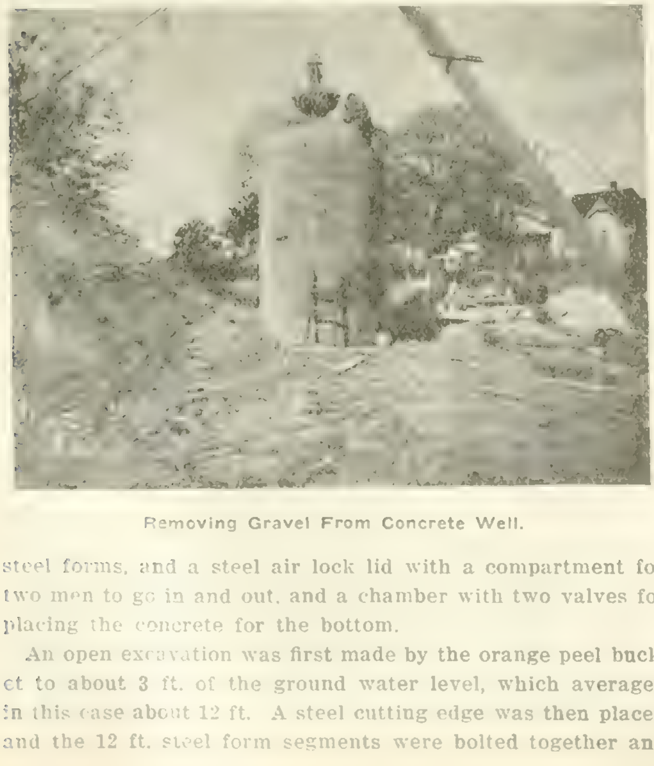
The Mansfield Engineering Co. of Indianapolis has varied from the usual method of shoring and pumping in the construction of deep well pits, and has met with success in using the caisson method of sinking, as well as perfecting an air lid for forcing the water out of the well by air, and placing a concrete bottom in same.

Placing 12-Ft. Steel Form Segments.

The purpose of these well pits was to provide water for the Indianapolis Water Co. from deep driven wells of 300 to 400 ft. depth by electric pumps placed at approximately the artesian head, thereby enabling them to pump the water from these wells to their pumping station nearby.

These well pits were of concrete, 8 ft. internal diameter, and varied in depth from 24 ft. to 33 ft. with a water tight reinforced concrete bottom. The walls were 1 ft. thick and reinforced.

The equipment consisted of a guy derrick and hoist engine, air compressor, 9 cu. ft. Haywood orange peel, concrete mixer, steel forms, and a steel air lock lid with a compartment for two men to go in and out, and a chamber with two valves for placing the concrete for the bottom.

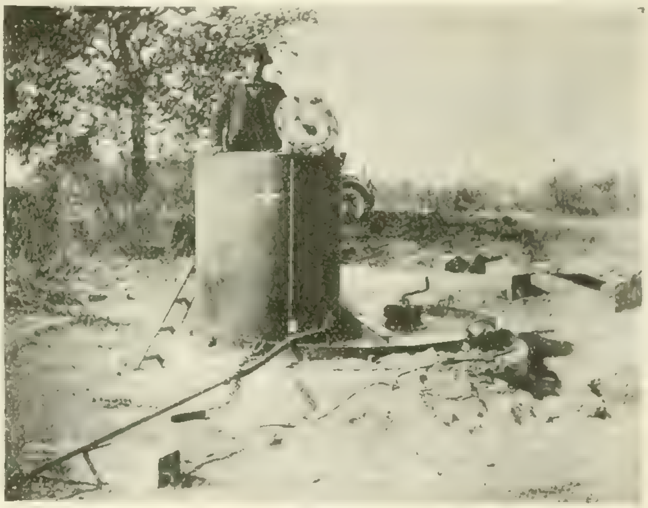


Removing Gravel From Concrete Well.

An open excavation was first made by the orange peel bucket to about 3 ft. of the ground water level, which averaged in this case about 12 ft. A steel cutting edge was then placed and the 12 ft. steel form segments were bolted together and reinforcing steel placed. The forms were guyed with four cables with ship turnbuckles. The concrete was hoisted in an ordinary bottom-dump concrete bucket by the derrick and dumped on a platform which rested on the inner form and then shoveled into the form by one man. Twenty-four feet were poured at a time.

After the concrete had set, the lower 12 ft. form segments were removed and also the cutting edge form. The gravel on the inside was then removed by the orange peel. As the gravel was removed, the concrete well lowered itself. The turnbuckles were kept tight which kept the well from leaning as it was lowered.

After the well had sunk the 12 ft., the upper form section was loosened and as the well was lowered, it slid on down the form. As most of the wells were more than 24 ft. deep, the upper form was tightened after the cutting edge had been sunk to the required elevation and the remaining concrete was poured. All forms were then removed and then backfilling was done around the outside of the well. When this last section was poured, 1 in. by 15 in. anchor bolts were placed in the top, so that the air lid, shown in the cut, could be bolted down. This lid was designed and constructed by The Mansfield Engineering Co. to withstand an upward total pressure of 100 tons. It has a three man compartment, a two valve chamber for placing the concrete in the bottom, air gauge, and telephone system. A gasket was placed between the concrete and lid, and then bolted down. A wood platform was hung under the lid, whereby a man could stand and regulate the lower valve for the concrete. A man on the outside operated the upper valve. These valves were ordinary flap valves and were screwed down.



The Air Lid.

Air was pumped into the well forcing the water out through the bottom. Eight to fourteen pounds pressure were needed, depending on the depth of water to be forced out. An air gauge showed the pressure. Concrete was then poured through the concrete chamber. The air was held about 48 hours until the concrete had set. The lid was then removed.

The Indianapolis Water Co.'s specifications for a 6 in. pipe, approximately 25 ft. long, with a special foot valve on one end and a valve and bolted flange on the other end, the 6 in. pipe to go down into the 10 in. casing and the 6 in. flange to be bolted to a special cast flange, which was to be put in flush with the bottom and leaded to the 10 in. casing.

A 10 in. test plug with a long adjusting rod and nut which could be adjusted from the top of the casing, was placed below the point where the casing pipe had to be cut off. The pipe was cut off by an oxwelding outfit and pipe removed by the derrick. The 6 in. pipe was then lowered by derrick to just above the floor. The test plug was removed and the 6 in. pipe immediately lowered into the casing and bolted to the lowered flange. The water that came up through the 10 in. pipe during this period was taken care of by a 4 in. pulsometer.

Eight of these wells were completed by The Mansfield Engineering Co. for the Indianapolis Water Co. during the past year, and also one well 30 ft. deep which was used as a water reservoir for the American Hominy Co.'s plant at Indianapolis.

Commercial Features of Water-Works Operation

Experiences of the Spring Valley Water Co. of San Francisco during the past three or four years, in the business end of its waterworks operation were outlined by Mr. O. E. Clemens, Water Sales Manager of the company, in a paper presented last November before the California Section of the American Waterworks Association. In his paper, an abstract of which follows, Mr. Clemens describes the methods employed by his company in overcoming a deeply rooted prejudice against water meters; the education of the consumers to the principles of equitable payment for service rendered and the value of the commodity used; the training of the individual in the proper uses of water with a resultant reduction in gross daily delivery that has saved the city from a disastrous situation; and how the company made friends of former corporation baiters and made boosters of knockers.

Why Meters Were Installed.—The Spring Valley Water Co. has some 20,000 commercial accounts consisting of factories, refineries, shops, railways, stores, hotels and apartment houses, and over 50,000 residential accounts represented by family dwellings consisting of houses and flats.

The commercial consumers have always paid for water service on a measured or meter basis. Prior to October, 1918, the residentials were assessed on the so-called flat rate schedule, this being based on the size of the house, number of fixtures installed and the area of the garden and lawn. The revenue derived from this source averaged up fairly well as a whole, but was sadly discriminatory and unjust as between consumers. More than half of the residential consumers paid from 25 to 100 per cent more than the value of the water they used, the remainder paying less, many of them using and wasting from 10 to 100 times as much as they paid for, as was proved by the records of test meters installed.

When the company began installing meters on the residential services during the summer of 1916 (these being set primarily for test purposes, as meter rates could not be applied to this class of consumers under the then existing ordinance) it met with a wave of opposition which was intensified by the radical elements, aided and abetted by a certain daily paper, which was in fact actuated more by personal animus than by any desire to serve the public.

Application being made to the Railroad Commission in the early part of 1918 for a uniform rate schedule, the company rushed the installation of meters, having the entire 50,000 set by October, 1918, when the Commission authorized the application of a modern and most equitable rate.

After two years of intensive educational and service work, the public is now thoroughly converted to meters and it can be stated with the utmost confidence that if the question should be put to vote, those in favor of returning to the former system of billing for water service would be hopelessly in the minority.

In addition to the gratification of having a satisfied public to deal with, the company has saved in the neighborhood of 10,000,000 to 12,000,000 gal. of water daily by the elimination of leaks and waste. This knowledge has produced a most comfortable feeling during the past year, a year of water shortage so serious that it affected indirectly all lines of business in the State of California.

How the Prejudice Against Water Meters Was Overcome.—In working out the problem of meeting the opposition and old-time prejudice, the company just used common sense—got the other fellow's viewpoint and met him on his own ground.

The keynote of the campaign has been and is yet "Education and Service." By "Education" is meant not only the education of the public but also of the company's employes as well. To all, whether the individual encountered is salesman or collector, service man or adjuster, railway ticket agent or conductor, Government postman or stamp clerk, the opinion formed of his company or institution is very largely based on his personal service to us. If he is arbitrary and a boor, uncouth or ignorant, he will convey a very poor impression of the people he represents. To the contrary, if he is gentlemanly, gives us the opportunity of airing our own opinions, can give an intelligent and logical explanation of the question in hand and is fair enough to admit an error and correct it, he at once commands our respect, with the result that his company goes up several points in our estimation. And when opportunity comes to say good or ill, the chances are that we will give his company the best of it.

Acting upon this idea, not a theory by any means, for it has been established as a fact, the Spring Valley Water Co. promptly proceeded to educate its employes first of all. Classes were held at the shop where they were shown the workings of the water meter, shown what a wonderfully accurate instrument it is and how seldom it can get out of order; how if it does go wrong, it is almost invariably in favor of the consumer. The time spent on this was well worth while, for the men gained full confidence in the instrument and could meet any and all comers on the subject. And many men were found in this city, otherwise very intelligent and well read, who possessed a blind and unreasoning prejudice against meters and honestly believed they could not be depended on for accurate registration.

The next step was to drill the company's personnel in the logic of the new rate schedule. This schedule is one that at first aroused much adverse comment, owing to the elimination of the familiar "minimum bill" and the substitution of the "monthly service charge," an item independent of the charge for water delivered. As this method of billing is a radical departure from the established custom, it may be well to give a brief explanation of the principles involved.

Principles of the "Monthly Service Charge."—In the supplying of water there are three distinct operations, the costs of which must be borne by the consumers:

1. Developing and protecting the water at its source, collecting it in large storage reservoirs, and pumping and conveying it to the city distribution reservoirs.

2. Distributing the water throughout the city through the main supply lines to the smaller regulating reservoirs, and finally through the distribution lines in each street.

3. Maintenance and repairs to meters and services, inspection of plumbing and fixtures for the consumers, reading meters, bookkeeping, billing and collecting.

The charge for "water delivered" is based on the cost of the first two items, which cost includes proper returns on the value of the properties involved, depreciation and maintenance. The charge for "water" in San Francisco ranges from 24 cts. for each 100 cu. ft. for domestic and small commercial consumers to 18 ct. per 100 cu. ft. for large industrial consumers. The reason for this distinction is that it costs relatively less to distribute water in large quantities than in small quantities.

The "monthly service charge" is based on the cost of the third item, which is largely the expense of the "sales" or "commercial" part of the business. The total charge as fixed for this item includes all items of expense beginning with the consumer's service line; and in addition the estimated cost of the water passing through the meter without being registered. This is known as "slippage." It amounts to a very considerable item, tests showing that the average is about 50 gal. per day on the standard ⅝-in. household meter and proportionately more on large meters. The total service charge as now fixed is 65 ct. per month for ⅝-in. meters, increasing through intermediate charges to $40 per month for the large 8-in. connection.

The service charge is a most equitable arrangement. It is fairer than the "minimum bill" method. The Railroad Commission, after thorough consideration of the principles involved, said in its decision authorizing the company to apply the new schedule:

> The minimum charge is invariably higher than the service charge, and it involves the payment by each consumer for a fixed amount of water regardless of whether or not he uses it. There is no answer known to us which can be made to the man who complains that under a minimum rate he is compelled to pay the same amount for 100 cu. ft. of water as his neighbor pays for 500 or 600 cu. ft. of water dependent on the amount fixed for minimum use.
>
> We believe that under the conditions and policies we are dealing with herein the service charge once established and thoroughly understood will be agreed to as the fairest and most equitable method of fixing rates.

The service charge is not an additional charge and does not mean higher rates. It is simply a different and more equitable way of distributing the cost of service among consumers.

Education of Public by Newspaper Advertisements.—In the education of the public at large, the company could not depend on the personal contact of its representatives. This, while good, was too slow a process. What the company wanted was results and it wanted them quickly. To meet this it went into the press with paid advertisements. It not only took space in the big dailies but also in the district newspapers, for these all have their sphere of influence and followers. It did not take up this phase of the work in a half-hearted and haphazard manner, either. Newspaper space costs good money and badly written and undigested advertisements are very poor investments. Like the other spokesmen for the company, its advertisements are taken as indicative of its attitude towards the public.

The publicity was put in the hands of an expert, a master of good English, one who could get to the heart of the subject and develop the human interest side of the question. The advertisements told the story in simple and effective language. The "whys" of metering were given. The new meter schedule was explained and arguments made against it by consumers were reproduced and answered. The causes of large water bills were enumerated and specific cases of cause and cure cited. The square deal was constantly preached—and lived up to by the company's operating forces. The public was invited to come to the company with its water troubles and to call on its service department for assistance.

Advertising Was Backed Up by Real Service.—All complaints, no matter how trivial, were thoroughly investigated and helpful letters sent out to the complainants. Defective fixtures were located and specific recommendations regarding repairs were made. Unnecessary and wasteful uses were pointed out and constructive criticism offered. As a result, instead of an office full of irate consumers with the figurative "blood in the eye" and "chip on the shoulder" attitude and a host of insulting letters in every mail, the company have only relatively few complainants at the information and adjustment window; asking, not demanding, an investigation of abnormal bills and leaving to the company entirely the question of the adjustment of the cost of water lost through the leaky fixtures. And hardly a mail delivery comes but it brings one or more letters of appreciation from pleased consumers.

The company has made over 30,000 inspections during the past two years; it has found 10,000 defective toilets, located thousands of leaking faucets, and hundreds of broken or cracked house pipes. It has also shown many large consumers, such as hotels, candy factories and the like, how to save from a fourth to a third on their bills for water. It has trained thousands of families in the proper and liberal use of water without wasting, not only for the household but for irrigation purposes. They have learned that plenty of water can be used in the home without making the meter work over-time; that a bath is not an expensive luxury, for it costs less than a cent; that in San Francisco 3 cu. ft. of water per square yard per month during the summer will keep the lawn green and the garden blooming on the sandiest of sand lots. The company has also taught them that a defective toilet or a carelessly used or forgotten garden hose can waste more water in a day than an ordinary family can use legitimately in a month.

The results accomplished and the good feeling developed have repaid a hundred fold the energy and money expended on this educational and constructive campaign. Aside from the tremendous saving of four billion gallons of water a year, previously wasted and benefiting no one, it is possible to point to concrete savings in operating expense, largely attributable to the changed attitude of the public and its wholesome effect on the morale of the company's employes.

The pumpage quantities are less. There is less malicious damage to equipment. Patrons now go out of their way to telephone, write or call at the office regarding broken services or leaks in mains. The claims on account of damages to goods in basements flooded by an occasional break are now more easily adjusted; very seldom does anyone try to hold up the company or get the best of it. Collection expense is less and losses through bad accounts are negligible; last year they were 0.1 per cent and this year they will be even less.

In the final analysis the company knows its policy has paid [illegible]

Cost of Rock Drop Construction for Alberta Irrigation Canal

By ROBERT S. STOCKTON.

Water was turned into the Secondary "A" Canal of the Western Section of the Canadian Pacific Railways Irrigation Block, during the summer of 1906. This irrigation system lies east of Calgary, Alberta, and the lands are about 90 miles east of the Main range of the Rockies, and fall rapidly eastward. The canals are stepped down from time to time by means of drops or falls. These structures were originally of timber. Most of these structures have been replaced by concrete Indian type notch drops.

During 1920, two of the old timber drops No. 7A and 9A were replaced with an inclined chute rock drop following the type used by the U. S. Reclamation Service on the Flathead Project, Montana. These drops were designed to carry a maximum discharge of about 600 sec. ft., and the design is shown in Fig. 1. The structure consists of a foot layer of gravel on which is spread a layer of cement mortar 1:3, and bedded in this is masonry about 1 ft. thick with baffle stones sticking up at about 3½ ft. intervals, and from 1 ft. to 1½ ft. above the general level of the masonry. The rock used was a hard blue limestone from quarries at Kananaskis, about 85 miles away. Sand was mostly from Medicine Hat, 145 miles away.

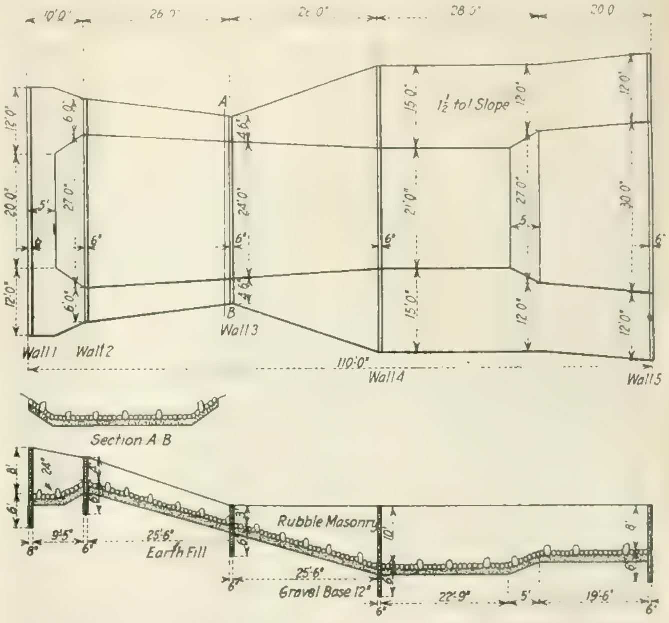


Fig. 1—Plan and Sectional Elevation of Drop 7A, Western Section C. P. R. R. Irrigation Block.

In the case of Drop 7A, a bypass was built to carry water around the old structure which was then pulled out and the ground shaped for the present structure, which is 110 ft. long and has a 2 ft. water cushion.

In the case of Drop 9A, it was possible to locate the new drop to one side of the old one, which was left in commission until the end of the season, and water will not be turned over the new drop until next spring.

Drop 9A meeting slightly different conditions from 7A, is 100 ft. long and has no water cushion. Both drops have a raised crest and drop the canal grade 10 ft. Gravel for underlaying the masonry came from the Morley Ballast Pit, 72 miles west and was unloaded alongside the main line track with a Lidgerwood unloader and hauled by teams ½ mile to Drop 9A, and 2 miles to Drop 7A. Cement and supplies were hauled from Strathmore, 2 miles to Drop 9A and 2½ miles to Drop 7A. There were some delays in receipt of materials for Drop 7A and delays due to labor shortage at Drop 9A, which was constructed later. During the wheat harvest, labor was not to be had, and Drop 9A was delayed, and finished about Nov. 15, after freezing weather had set in. This necessitated covering the work and heating materials. The completed Drop 9A was covered with 2 ft. of straw to prevent thawing and refreezing during chinook weather.

The year 1920 has witnessed the highest construction [illegible] in this district. The foremen received $6.50 per day straight time, or about $200 per month. Labor was paid at the rate of 45 ct. per hour for a 10 hour day. A small amount of pumping was required at each drop, but on the other hand, ditch water was at hand for the horses and for mixing mortar. The men were cared for in tents, and a camp mess with Chinese cook served meals, for which 40 ct. each was deducted. The mortar was a 1:3 mixture, and was taken from the mixer by means of wheel barrows and dumped at the required point as shown by the accompanying picture of Drop 9A. The mortar was mixed in a Jaeger Mixer, turned by a small gasolene engine.

(1) How Rock Was Placed in Mortar for Drop 9A. (2) Cutoff Walls and Beginning of Road Work on Drop 7A. (3) Completed Drop 7A; View Taken Aug. 3, 1920.

The cost record for Drop 7A Strathmore district was as follows:

	Labor cost.	Team cost.	Total labor charge.
Assembling camp	$46.50	$10.00	$56.50
Moving camp	69.25	17.00	73.25
Hauling lumber for bypass	25.75	12.00	37.75
Excavating for new drop	502.75	108.60	611.35
Care of stock	513.75	24.00	537.75
Removing old drop	547.70	60.00	607.70
Excavating for bypass	275.00	91.00	366.00
Building bypass flume	164.75		164.75
Building cutoff wall forms	253.95		253.95
Building temporary bridge	22.25	1.00	23.25
Hauling form lumber	27.00	12.00	39.00
Building dams	27.00	12.00	39.00
Pumping water	313.10	9.00	322.10
Unloading gravel	84.96	9.80	94.75
Hauling gravel, 260 yd	454.00	220.00	674.00
Hauling sand, 120 yd	261.00	127.00	388.00
Hauling rock, 266 ton	259.25	126.00	285.25
34 yd. concrete curtain walls	142.35	4.00	146.35
Reinforcement, concrete curtain walls	2.25	1.00	3.25
Hauling cement curtain walls	6.75	3.00	9.75
Excavating for curtain walls	271.35	60.70	332.05
Backfill for curtain walls	66.25	..	66.25
Building banks and filling	209.75	43.00	252.75
Placing rock in drop	536.00	32.00	568.00
Placing gravel foundation	294.50	17.00	311.50
Washing sand	148.50	2.00	150.50
Mixing mortar for rock	288.00	....	288.00
Riprap below drop	112.50	18.00	130.00
Riprap above drop	27.00	6.00	33.00
Removing dams	29.25	11.00	40.25
Hauling cement	51.75	25.00	76.75
Backfilling drop	88.50	6.00	94.50
Closing bypass	58.50	12.00	70.50
Removing flume	13.50	. .	13.50
	$6,194.65	$1,077.10	$7,271.75

Total labor cost as above	$ 7,271.75
13,664 ft. B. M. of lumber at $40	546.56
120 cu. yd. of sand	544.80
265 cu. yd. gravel (29 cu. yd., Keith)	431.50
266½ ton of rock	751.53
400 lb. nails	32.00
65 lb. baling wire	3.25
1,500 sq. ft. wire fabric	90.00
1,140 sacks cement	1,140.00
45 gal. gasoline, 2 gal. oil	25.00
Depreciation on mixer	25.00
	$10,861.39
Credit 50 per cent on lumber, $273.28, and old lumber, $50.	323.28
Actual cost, labor and material	$10,538.11

There are about 5,413 sq. ft. of rock masonry in Drop 7A and very closely 5,648 cu. ft. or about 209.2 cu. yd. Including the mortar bed in which the rock was laid, there was about 105 yd. of 1:3 mortar used or 50 per cent of the total yardage. This type of drop could be built without so many cutoff walls, but as an extra precaution, it was decided to put them in. The total cost of the cutoff walls, containing 34 yd. of concrete, was about $1,560 or at the rate of $45.90 per cubic yard. The labor cost was $22.95 per cubic yard of concrete placed, including all work on excavation, forms, etc.

The cost of work on Drop 9A was just about in proportion to the above, and is summarized as follows:

Total labor cost	$ 6,947.25
5,813 ft. B. M. of lumber at $40	232.52
195 cu. yd. sand	476.70
255 cu. yd. gravel	414.90
246 ton of lime rock	816.72
200 lb. nails at 8 ct.	16.00
50 lb. baling wire	2.50
2,000 sq. ft. of wire fabric	120.00
1,018 sacks cement	1,018.00
60 gal. gasoline and 14 gal. oil	35.00
2 loads cordwood	14.00
2½ ton coke	21.00
Dynamite and fuse	10.00
14 ft. 6-in. well casing	21.00
8 loads of straw for protection	16.00
Depreciation on mixer	25.00
	$10,186.59
Credit 50 per cent on lumber	116.26
Actual cost, labor and material	$10,070.33

There were about 5,008 sq. ft. of rock masonry in Drop 9A, and about 5,314 cu. ft. of masonry or about 196.6 cu. yd. the cutoff walls were a little longer than for Drop 7A and contained 41 cu. yd. There were 87 cu. yd. of 1:3 mortar which figures out 44.2 per cent or somewhat less than for the first drop. There was 5.7 sq. ft. of masonry to one sack of cement in Drop 7A and 6.3 sq. ft. of masonry to one sack of cement in Drop 9A.

Short Course in Highway Engineering at University of Illinois.—The 8th annual short course on highway engineering will be held Feb. 21-26 at the University of Illinois.

This short course has been planned to fill a long felt need for a meeting at which the specific and detailed problems of road and bridge design, construction and maintenance encountered by the engineers and contractors in the state could be discussed and in a large measure solved. City engineers and other city officials together with their assistants are also specially invited and special sections for the discussion of municipal problems of pavements, sewers, sewage disposal, water supply, lighting systems, special assessments, zoning and city planning, have been arranged. There are no prerequisites to the course and no fees will be charged. Information may be secured by addressing C. C. Wiley, Assistant Professor of Highway Engineering, 200 Highway Laboratory, Urbana, Ill.

Am. Soc. Mechanical Engineers to Meet in Chicago.—The spring meeting of The American Society of Mechanical Engineers will be held May 23-26 at the Congress Hotel, Chicago. Sessions are planned by the Professional Sections on aeronautics, fuels, management, material handling, machine shop, power, forest products and railroads.

Water Rates in Small Cities and Villages*

BY JOHN WILSON

A municipality which operates a water works plant is engaging in a commercial enterprise, and to be successful, it must furnish adequate service at reasonable rates, which must be in proportion to the service rendered and without discrimination.

The service rendered by a water works plant is of two distinct types; first, it must be ready to furnish water in comparatively large quantities under high pressure for short periods of time for the purpose of extinguishing fires, and second it must furnish ample quantities of suitable water for domestic purposes under moderate pressure at all times.

It is now generally conceded that all the expense incident to the former should be borne by the village or city at large. It is possibly unfortunate that the method of arriving at the compensation for fire service has generally taken the form of hydrant rental, as the number of fire hydrants has but a remote relation to the value or cost of the service. It has been estimated 60 to 80 per cent of the cost of water works plants in cities under 5,000 is incurred by providing reasonable fire protection.

Crosby, Minn., Situation. Two years ago the author was called on to report on the matter of rates for the village of Crosby, Minn., which problem involved some unusual and interesting features. Crosby has a population of approximately 3,500, and owes its existence largely to iron mining industries in the immediate vicinity. The water works plant was installed in 1911 by a private company and operated by it until two years ago, when the works were taken over by the village.

The franchise under which the company operated provided, in case the village wished to acquire title to the plant, that a board of appraisers should be appointed to determine the value and price to be paid. In accordance with this provision, C. T. Harding, of Virginia, was selected by the company, the author was appointed by the village and John W. Alvord, of Chicago, was selected as the third member.

The value of the plant, as fixed by the board, was $75,680. The plant at that time consisted of 12 ground water wells 70 to 80 ft. deep, electrically driven centrifugal pumps, a 100,000-gal. elevated tank, about 6 miles of distributing mains 4 to 10 in. in diameter, and 34 fire hydrants.

The conditions which led up to the village taking over the plant were largely due to the failing of private wells, due to mining operations, and many of the outlying districts were entirely deprived of water. The company in the meantime was naturally very reluctant to make extensions. Immediately upon taking over the plant the village spent over $56,000 in extending the distributing mains and also installed 35 additional fire hydrants.

Determining Fair Schedule of Rates.—The first step in determining what would be a fair schedule of rates was to estimate the proportion of the cost of the plant chargeable to fire protection. It was accordingly estimated that 51.6 per cent of the appraised value and 45.9 per cent of the cost of extensions might justly be charged to fire protection and the remainder charged to commercial service.

The village had 356 consumers and 155 householders who had asked for connections as soon as the extensions could be completed. The question naturally came up as to who should install the meters and lay the connection from the main to the curb box.

In connection with this, the author suggested that the village assume the cost of these two items, inasmuch as the number of consumers was small compared with the amount of distributing main; that many of the householders were men of limited means who would be tempted to carry water rather than connect with the mains were they required to bear all the expense; and, furthermore, one of the principal needs of the water department was paying consumers. It was also suggested that, in consideration of the village bearing this expense, all consumers should pay a service charge sufficient to cover the interest on the necessary investment.

[illegible] Decisions Regarding Service Pipes. In support of these suggestions, he quoted the following authorities:

In the case of Samuel M. Gilmore vs. Hackensack Water Co., the New Jersey Public Utility Commission ruled as follows:

> The Board concludes that the Hackensack Water Co. should take upon itself the burden of constructing all such connections as lie within the public streets up to and including the stop cock. The practice of the company requiring the consumer to pay for the installation of service pipe within the public streets and the stop cock is excessive and an improper and unreasonable charge. (Dec. [illegible], 1915.)

A similar ruling by the Wisconsin Railroad Commission was as follows:

> The question as to who should own meters appears to be settled. The only point to be decided here is whether or not services are a part of the facilities which the utility is expected to furnish. The logical conclusion seems to be that the utility should install and own services to the curb line. The utility, and not the consumer has the right to occupy the streets, and all pipes laid in the streets should be the property of the utility and we believe should be put in by the utility. The business of the utility is to deliver its product to the premises of the consumer. If the utility should own the mains through which water is carried to various sections of the city, it seems equally true that it should own all parts of the distribution system as far as the consumer's premises. The service pipe from main to curb is as much a part of the utility's distribution system as is the main itself. Both parts of the equipment have the same purpose—the delivery of water to the consumer's premises.

The California Railway Commission has reached the same conclusion (2 Cal. R. C. R., 989), stating it as follows:

> It is the duty of a water company to supply service connections up to the property line, and meters where meters are used, without direct expense to the consumer, seems clear both on principle and on authority. Such requirement seems entirely reasonable. The service pipe up to the property line and the meters, where used, are as necessary in the performance of the water company's duty to the public as its reservoirs, wells or mains. The consumer has no right to dig up the streets to lay a service pipe. That right belongs to the water company alone. It seems unreasonable to ask that the consumer should pay for service pipes and meters which are a part of the water company's system, which the consumer has no legal right to install and which are under the complete control of the water company.

The Service Charge.—The service rates suggested, which would be a regular monthly charge, in addition to regular meter rates, were as follows:

Meter.	Rate.	Meter.	Rate.	Meter.	Rate.
⅝-in.	$0.40	1¼-in.	$1.80	2½-in.	$6.00
¾-in.	0.75	1½-in.	2.50	3 -in.	8.00
1 -in.	1.25	2 -in.	4.00	4 -in.	12.00

One advantage of a service charge is that it tends to regulate the department's income and thus aid in meeting current expenses, while graduating the charge according to the size of meter and connection protects the department against consumers demanding much larger fixtures than necessary.

As closely as could be ascertained, the yearly consumption of water would be distributed as follows:

	Cubic feet.
Measured by ⅝-in. meters	1,440,000
Measured by larger meters	188,520
Passing meter without registry	50,000
Street sprinkling	290,000
Drinking fountains	180,000
Flushing sewers, etc.	30,000
Flushing trenches	10,000
Testing meters	600
Use in extinguishing fires	32,400
Total	2,221,520

It is very clear that the first three items should be paid for by the water consumer; the last one charged to fire protection; and the remainder should be charged to the village at large.

Unfortunately no means had been provided at the plant to determine the amount of water pumped. It was therefore assumed that the above would constitute about 60 per cent of the water actually pumped and that 40 per cent would be unaccounted for.

The total annual expenses for everything connected with the department was about as follows:

Interest on bonds $130,000 at 6 per cent	$ 7,800.00
Interest on other indebtedness $15,000 at 6 per cent	900.00
Clerk's salary, charge to Water Department	360.00
Superintendent's salary	1,800.00
Labor	600.00
Office supplies, postage, etc.	300.00
Fuel	50.00
Meter repairs	160.00
Maintenance, supplies and depreciation	1,500.00

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*[illegible]

Electric current ....
Insurance ....
Telephone ....

Total ....

Deciding on Water Rate that Would Yield Fair Returns.—It will be remembered that the extensions made to the distributing system were made necessary because of private wells becoming exhausted due to mining operations. The total number of houses to be served by these extensions was 331, while the number who declared their intention of taking water was but 155.

It is at once apparent that a rate for water which would yield a fair return on an investment such as incurred by these extensions would be unreasonable, and at the same time it would not be just or fair to place this additional expense on such consumers as the village already had.

The village was under moral obligations, at least, to contribute something to the relief of parties who had been deprived of well water. They were also engaging in a commercial enterprise, and should expect, the same as in any other business, to do so for a time at a financial loss.

It was therefore estimated a reasonable deficit over a fair return on these extensions would be $1,700 per year, which should be included in the proportion of the expense borne by the village at large.

From the foregoing data the rates which should be put into effect and the income to the water department would be as follows:

Hydrant rental, 79 hydrants at $75.00	$5,925.00
Deficiency on fair return on extension	1,700.00
Water used by village at 18 cents per 100 cu. ft.	1,000.00
Total due from village	$8,625.00
Service charge.	
400— ⅝-in. meters at 40 cents per month	$1,920.00
2—1¼-in. meters at $1.80 per month	43.20
1—1½-in. meter at 2.50 per month	30.00
1—2½-in. meter at 6.00 per month	72.00
1—3 -in. meter at 8.00 per month	96.00
Total from service charge	$2,161.20
1,628,520 cu. ft. of water at 25 ct. per 100 cu. ft.	$4,071.30
Making a total income from private consumers of	6,232.50
And a total income from all sources of	14,857.50

In this way the village would pay 58 per cent of the total annual expense and the water consumers 42 per cent.

The Wisconsin Commission ruled, in the case of Ashland, Wis., that the city should pay 54.5 per cent of all fixed charges; and in the case of Ripon, Wis., that the city should pay 75 per cent of all fixed charges; in which case it would seem that the distribution at Crosby would not be unreasonable.

Such items as clerk's salary were all charged to domestic service, while the fire service was charged with its share of interest on bonds, maintenance of fire hydrants, etc.

Water Rates in Effect in Minnesota.—The case of Crosby will illustrate fairly well some of the principles of arriving at proper rates in a given case. It is now in order to consider briefly the rates now in effect, throughout the state. The following figures are necessarily not exact, but they are taken from about 140 towns and are therefore reasonably representative.

Fifty-seven per cent of the water plants in the state receive nothing whatever from the municipality in the way of hydrant rental or payment for fire protection. Where hydrant rental is paid, it ranges all the way from $4 per year per hydrant to $140, the average being about $35.

Seventy-eight per cent of the towns pay nothing for water used for public purposes, such as street sprinkling, while of those who do pay, 69 per cent do so on a flat rate basis, without regard to the amount of water used.

In commercial service, about 44 per cent are on a strict meter basis, 36 per cent on a combined meter and flat rate basis, and 20 per cent are on a flat rate.

The rates in most cases are on a sliding scale, decreasing as the amount of water used increases. The most extreme case is a town of a little over 3,000, where they have 21 different rates for water and 20 different rates of discount for payment of bills when they become due.

In most cases the revenue derived from commercial service is not sufficient to cover the department's needs, and certificates of indebtedness are issued. These certificates bear 6 per cent interest and in many cases can only be disposed of upon a discount of about 10 per cent. Paper of this kind is allowed to accumulate until a special levy in taxation is made or bonds issued for paying off the indebtedness. The whole procedure is an expensive and extravagant way of doing business. In consideration of the present state of the money market, many towns would do well to revise their water rates and place their departments on a cash basis.

Installation and Ownership of Service Mains.—A full legal discussion relative to who should bear the cost of installing service mains and as to the ownership of such mains when installed would of itself necessitate a very long paper. The following discussion applies more particularly to villages and municipally owned plants.

As to whether the consumer or the municipality should bear the cost of installing the service mains, the Minnesota laws very clearly leave this to the discretion of the governing body, which may require the consumer to pay part or all of the expense, or, on the other hand, may install the service entirely free of charge as it may deem advisable.

The State Attorney General's office has handed down an opinion that it is customary in Minnesota to consider the service pipe from the main to the shut-off box a part of the main.

It is very evident from the Minnesota statutes themselves that the main and the service main are considered as two distinct features of the system, the assessment for the first being limited and spread over a term of five years, while the assessment for the latter is limited only by the cost and must be paid in three years.

However, the Attorney-General's office may not be so far wrong after all, for when we come to the ownership of the service main, or vested title therein, it seems a settled question that the village or utility has title to both notwithstanding the fact that the consumer may have paid in full the cost of installing the service, and is in this way considered an essential part of the main.

John W. Alvord, in a paper read before the second annual convention of the New Jersey Utilities Association, cites the case of the Knoxville Water Co. wherein in valuing the property for a rate case, the company presented to the court the claim that all services were the property of the company, whether provided at the company's expense or at the expense of the private consumer. On this point the Master's opinion was as follows:

> In the matter of service, there is much difficulty, not as to price, for the proof seems to be with complainant (water company). Defendant's plumber witnesses when under cross-examination rather confirm it. Defendant says, and proof shows, that consumers were made to pay for all but 123 of the 4,323 services stated. . . . . Complainant says it actually owned these connections, ... they are in the streets and cannot be changed by the consumer. In case of competition, this consumer would not be permitted to connect his with another main. . . . . The contention is that no matter how obtained, the property is theirs and the charge heretofore made was an additional charge for water at that time, etc.
>
> I see no way of resisting this conclusion, although I confess to much sympathy with defendant's contention that the citizens having paid for it should not be charged an interest on its value.

The master then allowed the sum of $38,714.00 for the service pipes.

The U. S. Supreme Court in passing upon this case examined the allowances of the master in detail, making no deductions from the master's findings on the value of services. The Supreme Court refers to the service pipes in the following language:

> "The first fact essential to the conclusions of the court below is the valuation of the property devoted to the public use, upon which the company is entitled to earn a return. That valuation ($608,000) must now be considered. It was made up by adding to the appraisement in minute detail all of the tangible property the sum of $10,000 for organization, promoting, etc., and $60,000 for going concern. . . . . The cost of reproduction is not always a fair measure of the present value of a plant which has been in use for many years. The items composing the plant depreciate in value from year to year in a varying degree. Some pieces of property, like real estate, for instance, depreciate not at all, and sometimes, on the other hand, appreciate in value. But the reservoirs, the mains, the service pipes, structures upon real estate, standpipes, pumps, boilers, meters, tools and appliances of every kind begin to depreciate with more or less rapidity from the moment of their first use."

It will thus be seen that the master included the service pipes in his valuation on the theory that title was in the company, although paid for by the consumer without any allowance in the reproduction cost for the contribution, and that the United States Supreme Court, by inference at least, affirmed his report as to the service pipes being the property of the water company.

Mr. Alvord also referred to a case presented to the United States Supreme Court in the Washington Gas case (Washington Gas Co.'s. District of Columbia, 161 vs. 316, 326). Here the company wish to disclaim all title to the service pipe on the ground that it had been paid for by the consumer, and thus avoid liability because of a defective service box. Mr Justice White, speaking for the court, said:

> The plan [illegible] contemplated by the [illegible] of the gas company was the supplying of gas to be [illegible] to consumers, and it is obvious that this could be done without making a connection between the street mains and abutting dwellings. When such connections are made with the mains they receive from them and convey into dwellings highly inflammable material, which [illegible] is [illegible] from the mains themselves. It must therefore necessarily have been contemplated that such connections with the mains as were from their very nature incidental to an inseparable connection with the consumption of gas should be a part of the apparatus of the gas company, and be under its control, rather than under that of the city or the property owner.
>
> Indeed the control by the gas company of the connection from its [illegible] to the point of use is [illegible] absolutely necessary to make it possible for the company to carry out the [illegible] purpose of its charter [illegible] the [illegible] and mains.
>
> Moreover, the provisions of the charter show that it was thereby contemplated that the connection between company's mains and the places where the gas was to be consumed should be made by the gas company, and become a part of its apparatus.
>
> The charter does not confer the power upon those desiring a supply of gas, but gives such power to the company. . . . .
>
> We conclude, therefore, that the duty was imposed upon the gas company to supervise and keep the gas box in repair. This duty not only did not conflict with the charter of the company, but, on the contrary, is sanctioned by its tenor and is imposed as an inevitable accessory of the powers which the charter confers.
>
> Nor do we think that this duty was affected by the circumstances that the cost of the labor and materials used in the construction of the connection and gas box was paid by an occupant or owner of property, who desired to be furnished with gas. As the service pipe and stop cock was a part of the apparatus of the company and was used for the purpose of its business, it is entirely immaterial who paid the cost or might in law on the cessation of the use of the service pipe and gas box by the company be regarded as the owner of the mere materials.
>
> Certainly, it would not be claimed that if the box and its connection became so defective or out of repair that gas escaped therefrom and caused injury the company could legally assert that it was under no obligation to take care of the apparatus because of the circumstances that it had been compensated by others for its outlay in the construction of the receptacles from which the gas escaped.
>
> The argument seeking to distinguish between the service pipe and other appliances of the gas company and the gas box so as to make the company liable for one end and not for the other is without [illegible]. All these appliances were parts of the one structure put [illegible] and used together for the purposes of the company.

The conclusions reached after investigating all available court decisions are that the consumer in paying all the costs incident to installing service mains does not acquire ownership, but is simply making a contribution, paying in advance for anticipated services or paying in part for the enhanced value of his property because of such installation.

By assuming the burden of installing service mains, the consumer supplies a portion of the necessary capital, and is entitled to consideration to that extent in the rates charged for water service.

The Minnesota law in leaving the question as to who shall furnish the capital for installing service mains, the consumer or the village, to the discretion of the governing body, seems entirely proper, for in this way the work can be financed by the party who can do so most advantageously.

Cost of Water Meter Repairs at Los Angeles, Calif. The following table from the annual report of the Board of Public Service Commissioners of Los Angeles, Calif., for the fiscal year ending June 30, 1920, shows the cost of meter repairing from July 1, 1919, to June 30, 1920, for Los Angeles, San Pedro and San Fernando Valley.

[illegible]	Size. In.	Labor cost.	Meter cost.	Over head.	Total cost.	Average cost per meter.
[illegible]	5/8	$3,333	$6,136	$ 946	$10,416	$1.39
573	3/4	313	535	84	933	1.63
237	1	181	317	49	548	2.31
194	1½	189	433	62	684	3.53
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
131	3	140	327	46	515	3.95
423	4	371	1,152	152	1,677	3.95
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9,378	*	4,871	9,838	1,471	16,181	1.72
16,[illegible]	*	1,440	.....	144	1,584	0.094
Miscellaneous work on [illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*All tested.

Comparative Costs of Drifting and Slow Sand Drifters at Toronto

The total annual cost per million gallons of Toronto's drifting sand filter is practically the same as the slow sand filter at its best when proper allowances are made for differences in operating conditions, interest on bonds, etc., according to a paper presented by James Milne, at the General Professional meeting of the Engineering Institute of Canada, held at Toronto, Feb. 2, 1921. The following data and costs are taken from the paper.

The slow sand filter plant has been in operation for eight years and the drifting sand plant 3½ years. Except for one month in 1912, the slow sand plant has been in continuous service. The average run of the filters, since 1913, is 21 days. In the winter it takes one day to rake and four days to scrape a filter, and in the summer it takes half the time to scrape, while raking is the same. Turbidity has not seriously affected the output. The drifting sand plant during 1919 had an average run of about 1¼ days, which is low due to large quantities of alum used to combat heavy pollution, and recent results show that the run will be from 3 to 7 days. A filter is out of commission about 35 minutes for washing.

The actual costs of operation are taken from the official records, while the equivalent costs are those based upon equal construction costs, together with equal rates for interest and sinking fund. Costs of operation are given for equal working conditions which means both plants operating at their safe capacities. Quantities are in Imperial gallons.

With the proper allowances for equipment and units which serve both plants, the total cost of the slow sand plant is $934,404, and for the drifting sand, $1,090,811. The former has a safe capacity of 32 and the latter, 50 million gallons per day, so that the cost per million gallons for construction would be $29,200 for the former and $21,817 for the latter.

On an annual cost basis two years, 1918-1919, have been taken. The following table shows the actual costs of the two plants:

Combined cost for 1918-1919.	Slow sand.	Drifting sand.
Net yield of filters in million gallons	20,425.17	25,278.11
Actual cost of administration, operation and maintenance	$148,940.17	$292,984.96
Total interest and sinking fund	$97,049.02	$154,608.92
Cost of operation and maintenance per million gallons	$ 7.29	$11.59
Interest and sinking fund per million gallons.	$ 4.75	$ 6.11
Total cost per million gallons	$12.04	$17.70

As the bonds for both sections of the plant do not bear the same rate of interest and sinking fund the above could not be considered a fair comparison. By substituting the calculated amount for interest and sinking fund on corrected basis and revised equivalent costs, we have:

	Slow sand.	Drifting sand.
Cost of administration, operation and maintenance as before	$148,940.17	$292,984.96
Interest and sinking fund, 2 years	132,685.22	156,984.00
Total	$281,625.39	$449,878.96
Cost of administration, operation and maintenance per million gallons................	$ 7.29	$11.57
Interest and sinking fund per million gallons.	$ 6.50	$ 6.20
Total cost per million gallons	$13.79	$17.79
Ratio of cost per million gallons	100	129

It is the practice to operate the slow sand plant to its maximum while the drifting sand plant merely makes up the difference required for the total consumption. The average daily output for 1918-1919 was 27.98 million gallons for the slow sand and 34.63 million gallons for the drifting sand plant. Thirty-two million gallons per day has been given as the safe average daily capacity for the slow sand plant.

To increase the output of the slow sand plant from 27.98 to 32 million gallons would mean operating a large steam-driven centrifugal pump.

In order, however, that the slow sand plant should not be taken at a disadvantage, we will assume the plant actually filtered 32 million gallons daily without the use of the steam auxiliary raw water pump. The increase of 4 millions daily would cost for electric power and sundries, under normal conditions, about $2,500 per year. Labor costs would remain as before.

The drifting sand plant has shown it can readily give 54 million gallons daily and placing the same at 50 million we are on the conservative side. The drifting sand plant in 1918-19 was operated at 69.2 per cent of its capacity taken at

50 million. To increase this to 50 million gallon rate [illegible] that it be placed on the same basis as the slow sand plant, the following would be added to the cost:

Increase in electric power 1,800,000 K.W.H. at 0.175 ct.	$ 3,150.00
15.4 mill. gallons per day at $1\frac{1}{4}$ grains alum per gallon [illegible] $14.20 per ton	[illegible]
Sundry additional repairs, estimated	[illegible]
For one year	[illegible]

The figures based on both sections of the plant working at capacities of 32 and 50 million gallons respectively, together with interest and sinking fund based on equal financial rates and equivalent construction costs, are therefore as follows:

	Slow sand.	Drifting sand.
Total yield in mil. gals.—100% 32 and 50 mill. gallons respectively	23,360.00	36,500.00
Cost of administration, operation and maintenance, as before	$148,940.17	$292,984.96
Additional cost for 2 years as shown above	5,000.00	52,100.00
Interest and sinking fund	132,685.22	156,894.00
	$286,625.39	$501,978.96
Total cost per million gallons	$12.26	$13.75
Ratio of costs	100	112

Drifting sand costs 12 per cent in excess of the slow sand.

There is still another feature, and an important one, which must not be lost sight of and which will have considerable bearing in the future on the operation of the drifting sand plant. By chlorination with filtration a large saving in alum may be effected. The alum used in 1918 and 1919 amounts to 2,252.83 tons costing $99,595. It is estimated that with pre-chlorination, approximately $25,000 per year can be saved or $50,000 in two years. If these estimates are confirmed the following would hold good:

Cost of administration, operation and maintenance as above	$345,084.96
Deduct for alum	50,000.00
	$295,084.96
Cost per million gallons, administration, operation and maintenance	$ 8.08
Cost per million gallons, interest and sinking fund	4.29
Total cost per million gallons	$12.37

or about the same as slow sand plant under the very best operating conditions:

The drifting sand plant maintenance costs will be reduced about $7,500 per year when the changes to sandwashers, etc., have been completed. This amount has not been taken into account in the above final calculation.

The following conclusions may be drawn from the results of the two plants:

(1) The cost of the slow sand plant, owing to favorable local conditions, was considered extremely cheap. The drifting sand plant did not share this advantage.

(2) The space occupied by the slow sand plant is eight times that of the drifting sand for given output.

(3) The effluent in both cases is excellent.

(4) There is no scour on the plates due to the drifting of the sand.

(5) The principle of the drifting sand has proved to be sound and the continuous sand-washer is a success.

(6) Ice forming on the slow sand beds retards sand-washing operations. Cold weather does not affect the drifting sand.

(7) Prolonged periods of turbidity affect both types, but the drifting sand plant recovers its capacity more quickly.

(8) Labor has to be of a higher grade in the operation of the drifting sand filters than that required for the slow sand filters.

(9) Pre-coagulation and sedimentation unnecessary with the drifting sand plant.

(10) By chlorination with filtration and both plants operating as last herein before mentioned, the cost, including administration, operation and maintenance, interest and sinking fund, will be practically the same in both plants.

Production of Lime in 1920.—About 3,350,000 short tons of lime, valued at $33,518,000, were produced and sold in the United States, including Porto Rico and Hawaii, in 1920, according to an estimate made by Herbert Insley, of the United States Geological Survey, Department of the Interior, from figures furnished by the principal producers. The quantity reported is more than that produced in any year since 1917 and is 9 per cent more than that produced in 1919. It does not, however, quite equal the average pre-war production. The value of the lime produced in 1920 is considerably more than the value in any previous year. The average value per ton in 1920 was $10, in 1919 it was $9.50, and in 1918, $8.36.

Transformer Cost Data

By D. D. Ewing,
Professor of Electric Railway Engineering, Purdue University, Lafayette, Ind.

Transformers constitute an important part of the equipment which goes to make up the physical plant of an electric power company. While quotations on transformers from the manufacturers are always easily obtained, the engineer often has need for cost data in a concise form. Such data are of especial value in making or checking appraisals and in making tentative estimates on new construction.

Comparative cost data on standard lighting transformers, 2,200/220/110 volts, 60-cycle, single phase, are given in the accompanying table. The data for 1916 and 1920 represent the average costs for these years as nearly as it could be obtained, the costs being f.o.b. factory to the ordinary purchaser:

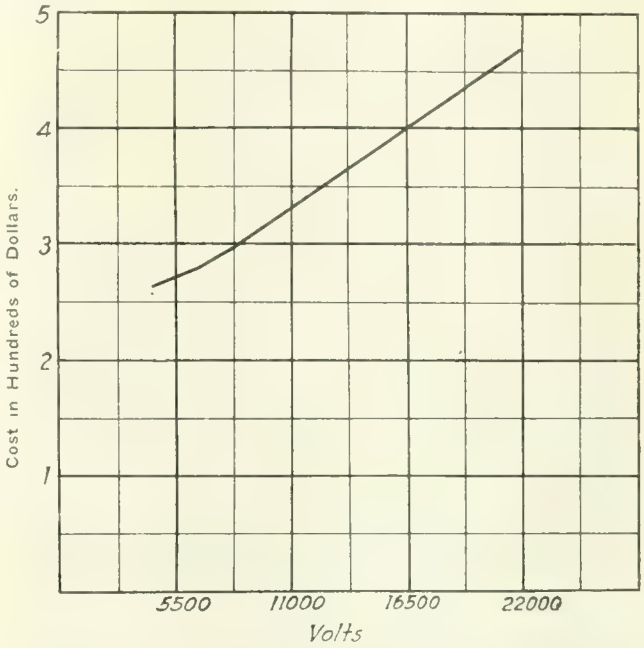

Fig. 1—Variation of Cost With Voltage for a 25 KVA., Single Phase, 60 Cycle, 220/100 Volt Secondary, Distributing Transformer.

COMPARISON OF TRANSFORMER COSTS.

KVA. capacity.	10-yr. avg. 1909-19.	1916.	1920.
1	$ 20.43	$ 23.90	$ 27.09
2	28.81	33.10	38.43
3	35.93	42.10	49.11
5	50.38	58.70	66.15
$7\frac{1}{2}$	82.29	77.00	88.20
10	..	94.91	107.73
15	111.75	125.00	143.64
20	131.91	153.00	......
25	162.78	181.00	206.64
30	178.33	206.00	......
$37\frac{1}{2}$		..	273.42
50	272.55	298.00	335.16

The cost of a transformer depends on the capacity, voltage, frequency, the number of phases for which it is designed and the method of cooling. For fixed conditions of voltage, frequency, phase and method of cooling the cost varies directly as the capacity, within limited ranges of the latter, and the equation showing the relation between cost and capacity for a given range is therefore a straight line.

The effect of voltage on cost, for a given capacity, is shown in Figs. 1 and 2. Fig. 1 shows the costs of 25 KVA transformers for primary voltages ranging from 4,400 volts to 22,000 volts. These transformers are designed for use in 60-cycle, single phase service on distributing transmission lines in small towns and rural communities. The secondary voltages are 220/110 volts. The upper part of the graph is a straight line, the increase in cost amounting to $13 per kilovolt increase in voltage. In Fig. 2 are shown similar graphs for 2,500 KVA 60-cycle, single phase, 2,300-volt secondary transformers for industrial power and lighting service. For the upper portion of the graph of the self-cooled transformer the increase in cost amounts to $[illegible] per kilovolt increase in voltage. For the water cooled transformer the increase is $65 per kilovolt.

The costs of several lines of transformers are given in the following equations, all costs being f.o.b. factory to the ordinary purchaser, in July, 1920:

Pole type transformers for 60-cycle, single phase service, 220/110 volt secondaries.

(1) For 4,400-volt primary and in capacities of from 1 to 10 KVA:

Cost = $36 + $10.60 × KVA.

(2) For 6,600-volt primary and in capacities of from 1 to 10 KVA:

Cost = $50 + $11 × KVA.

(3) For 11,000-volt primary and in capacities of from 1 to 10 KVA:

Cost = $100 + $10.30 ×KVA.

(4) For 4,400-volt primary and in capacities of from 10 to 50 KVA:

Cost = $75 + $7 × KVA.

(5) For 6,600-volt primary and in capacities of from 10 to 50 KVA:

Cost = $100 + $7 × KVA.

(6) For 11,000-volt primary and in capacities of from 10 to 50 KVA:

Cost = $135 + $7.30 × KVA.

(7) For 22,000-volt primary and in capacities of from 10 to 50 KVA:

Cost = $300 + $6.50 × KVA.

The above transformers are especially well adapted for service in small towns and rural communities where only one transformation from the transmission voltage to the service voltage is necessary.

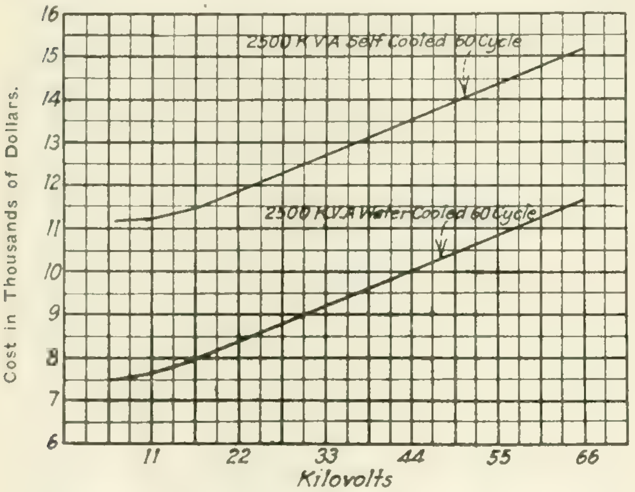

Fig. 2—Variation of Cost With Voltage for 2500 KVA., Single Phase, 60 Cycle, 2300 Volt Secondary, Transformers for Power and Lighting Service.

For small towns where a 2,300-volt primary distribution system is preferable the transformers whose cost data follow are better adapted. These transformers are of the self-cooled pole type with 2,300-volt secondaries and are designed for 60-cycle, single phase service.

(1) For 6,600-volt primary and in capacities of from 10 to 50 KVA:

Cost = $100 + $7.60 × KVA.

(2) For 11,000-volt primary and in capacities of from 10 to 50 KVA:

Cost = $140 + $7.20 × KVA.

(3) For 22,000-volt primary and in capacities of from 10 to 50 KVA:

Cost = $300 + $6.60 × KVA.

Cost data for industrial power and lighting transformers are presented in the following equations. These transformers are all 60-cycle, single phase, 2,300-volt secondary and are in capacities of from 500 to 2,500 KVA.

Self-cooled:

[illegible] primary: Cost = $1,000 + $4.2[illegible] × KVA.
(2) For 11,000-volt primary. Cost = $1,300 + $4.11 × KVA.
(3) For 22,000-volt primary: Cost = $1,700 + $4.15 × KVA.
(4) For 33,000-volt primary: Cost = $2,100 + $4.31 × KVA.
(5) For 66,000-volt primary: Cost = $3,750 + $4.65 × KVA.

Water cooled:

(1) For 6,600-volt primary: Cost = $1,500 + $2.45 × KVA.
(2) For 11,000-volt primary: Cost = $1,600 + $2.47 × KVA.
(3) For 22,000-volt primary: Cost = $2,000 + $2.62 × KVA.
(4) For 33,000-volt primary: Cost = $2,500 + $2.72 × KVA.
(5) For 66,000-volt primary: Cost = $4,200 + $2.92 × KVA.

The costs for the water cooled transformer do not include the costs of the water piping outside of the transformer case and of the circulating pump equipment.

Meter Reading and Billing System of Spring Valley Water Co.*

The Water Sales Department consists at present of 113 people, 92 men and 21 women and girls. As the company is now operating under changed conditions, a comparison with the records of the month of October, 1915, when all residential services were unmetered, will be of interest. These are produced herewith:

	October, 1915.	October, 1920.
Active consumers	66,000	72,000
Daily delivery to city reservoir (gallons)	45,187,000	36,566,000
Gross revenue	$298,391	$331,124
Meter readers	9 (⅔ time)	13
Shut-off men	7	4
Plumbing and rating inspectors	19	8
Bookkeepers and billers	14	28
Addressograph room	3	2
Field collectors	24	21
Builders and contractors supply	7	1
Dock and shipping supply	4	4
General office assistants and clerks	32	32
Total employes	119	113

The smaller force now maintained handles a larger business than the company had in 1915 and gives the public far more satisfactory personal contact. This reduction in the force and the delivery of a higher standard of public service is due partly to the reorganization of re-alignment of the department; partly to the 100 per cent metered condition of the business; partly to improvement of some methods, the elimination of others and the introduction of new methods. In addition credit must be given to the changed attitude of the public, which has been meeting the company in a co-operative way, this greatly improving the morale of the employees and indirectly increasing their efficiency.

Meter Reading and Records.—Of the 75,000 active and temporarily non-producing meters in San Francisco, 3,500 are installed in the basement areas under the sidewalk in the downtown section, the remaining 71,500 being in the open along the curb line in the sidewalks.

All meters are read once a month, the entire city being covered by 13 readers in 21 working days. The average on the basement work is from 100 to 151 per day, in the semi-commercial district where they are delayed by traffic, merchandise on the sidewalk and other handicaps, about 250 or 300 per day, while in the open sections, solidly built, they average better than 500, some runs reaching 700 in seven hours reading time. The average throughout the month is 300 per day per man for the 21 days.

On the five remaining days of the month the men take "covered" readings, clean dials and work up reports on broken boxes, and on the last day take the municipal and corporation readings.

The meter readers use a canvas-covered, loose-leaf field book of the steel tape type, holding sheets 4½x7 in., having a capacity of two years' records. These sheets are crimped at the lower or binding edge, permitting them to lie flat when the books are opened. This feature is quite an advantage to the reader and especially so to the ledger posters and billing machine operators.

These books, each one covering a man-day route, are turned over by the chief of the readers to the head bookkeeper each night. These are recorded by him on a schedule sheet on which a record is kept of the various operations until the completed bills are turned over to the Collection Department.

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*From a paper presented last November before the California Section of the American Waterworks Association by O. E. Clemens, Water Sales Manager of the Spring Valley Water Co., San Francisco, Calif.

Billing and Collecting.—The consumers' ledgers are of the same loose-leaf, steel-tape, crimped-sheet type, each ledger holding from 500 to 1,000 accounts, each sheet having a capacity of four years' records. On these sheets is carried the full record of the account, showing name, address, account number, meter number and records of changes, together with any and all records of Turn-ons, Shut-offs and Allowances.

The meter readings are posted on the ledgers, computations made and after a memorandum of unpaid balances due is made on the meter sheets they are turned over to the billing machine operators.

The bills used are of the single bill type, with an office memorandum stub and remittance stub. The company does not send receipts for mailed remittances except when demanded. The consumer retains the body of the bill and encloses the stub with his check. When bills are paid in the office or to the collectors, the body of the bill is receipted and returned to the consumer, the stub being turned in with the collector's cash. The credit postings are made on the consumers' ledgers by a night crew of three men.

The form of bill now in use was adopted after investigation of the bills and methods of a dozen large utilities. It is less cumbersome than the duplicate bill, requires only one half the amount of paper stock and eliminates carbons. The number of bills rewritten on account of being misplaced by consumers is negligible, less than 1,000 per month out of nearly 75,000, so this argument against the single type of bill is eliminated.

After the bills are written they are checked against the ledger record and errors in entry and computation corrected, then passed on to the Collection Bureau. There they are sorted, the mail bills turned over to the mail clerk, the bills to be paid by the realty agencies are assembled, and the others put in the street boxes or racks. These are re-assembled each day according to routes and given to the collectors that evening so they can start direct on their routes the next morning without losing time in coming to the office.

The mail bills are placed in a special window envelope made to fit the bill with attached stub without folding. This is a material advantage, as much time is gained by avoiding the folding of the bill before inserting it in the envelope.

There are 14 collectors on the regular field work, following the same route covered by the meter readers and completing the city in 24 working days. One collector handles realty agencies and downtown bills, and six men are on followups, closing bills, contractors' bills and bad bills. They are also in reserve to fill in the vacancies due to sickness, vacations and miscellaneous emergencies.

Of the 73,000 monthly bills, 4.5 per cent are held at the office for the consumers, 7.5 per cent go to realty agents for payment, 10 per cent are mailed to the consumers and the remaining 78 per cent are presented by the collectors. The company encourages mailing of bills, especially in sections where it can be made universal. The collectors bring in the money for two-thirds of the bills presented by them, the remaining third being sent or brought to the office or secured by the follow-up or "second-line" men.

The cost of field collections, on bills actually collected, averaged during the year 1919, 2.03 per cent or 6.96 ct. per bill as against 2.24 per cent or 8.37 ct. per bill in 1917, although wages in 1919 were higher. This is due to the reorganization and to the change of public attitude referred to before. The follow-up, closing account and bad bill collection expense is considerably more, from five to ten times as much. But the company can afford to spend some money on this, as losses from delinquent accounts may become a very serious item if they are loosely handled. While the company is very liberal with regular customers and with those out of work or sick, it will gladly spend the entire amount of the account, and more if necessary, to collect a bill from a crook or a chronic dead beat. The moral effect of this procedure on this class of individuals is good. It also adds zest to the game and keeps the force keyed up to a proper spirit and on its mettle.

Engineers' License Bill in North Carolina.—The State Senate of North Carolina has passed a bill licensing engineers and land surveyors which was introduced in the legislature by the North Carolina Society of Engineers—North Carolina Assembly of the American Association of Engineers.

Some Notes on Electrolysis

In the January Journal of the American Waterworks Association, Gellert Alleman, Professor of Chemistry, Swarthmore College, contributed an interesting discussion of some of the practical points brought out in the paper "Some Aspects of Electrolysis," he presented at the Montreal Convention of the Association. His discussion follows:

The writer cannot recommend any single method of installation as a cure-all for electrolysis, any more than a physician can relieve all diseases by the application of one particular remedy. Every pipe system must be considered individually. There are a number of methods employed in attempts to mitigate the damage done by stray currents. It is stated by advocates of the so-called three-wire system that little damage will result from electrolysis by this means of distribution. These statements are contradicted by facts. In a number of places that the writer knows of the three-wire system is responsible for very serious electrolytic corrosion. Theoretically, this system of distribution is interesting; but, in practice, the adjustments have not been made perfect and the desired electrolytic equilibrium has not been established.

The drainage of pipes by means of copper cables is an important attempt towards mitigating the damage by electrolysis. If a sufficient number of locations are intelligently selected, and a sufficient number of copper cables, having the desired capacity, are installed, nearly all of the current is returned over these metallic conductors. The current causes no damage when taken off in this manner. It must be remembered, however, that even with the installation of copper cables, small amounts of current may leak from pipes through the soil at points distant from these cable connections, and electrolysis will result under these circumstances.

Insulated pipe joints should not be installed in localities where electrolytic corrosion may take place. When such installations are made and such a piping system is in a path between some other sub-surface structure, for instance, a large water main, the current, in passing through the earth, will get on an insulated section of pipe and is then bound to leave it for the metal having the greater conductivity. In so doing it will corrode the insulated pipe. Such destruction will take place much more rapidly than if the insulated pipe were part of a continuous conductor. In the case of a pipe line made up of insulated sections the current is apt to leave the pipe, through the earth, get on to the next length of pipe, leave it again through the earth, and again enter and leave the pipe many times. Since one ampere, flowing for one year, will dissolve or corrode 20 lb. of iron provided it leaves the pipe but once, when this amount of current leaves the pipe twice it will dissolve 40 lb. of iron; and if it enters and leaves the pipe ten times it will dissolve or corrode 200 lb. of iron.

Recently the author made extensive electrolytic tests in a large city. In order to determine the "drop" on various sections of track, connections were made, at the two track ends, through telephone wires and recording instruments were employed to indicate the differences of potential between the points mentioned. In one case, connections being made 3 miles apart, the track "drop" was 90 volts. An examination of this track showed that workmen were making repairs and numbers of rail bonds were broken. After these rails were properly bonded the same track "drop" was again determined and it was found to be 18 volts. The efficient bonding of the rail is, of course, one of the best safeguards we have. Another suggestion in connection with rail bonding is this: Every time a new power station is put in service the electrical conditions are changed. New power stations and the installation of new tracks should always be accompanied by proper electrolytic protection of the pipe system.

In general, those systems should be employed which will effectively take the current off the pipe through metallic circuits, so that the current does not leave the pipes through the earth and thus dissolve or corrode the iron or the lead. This can be brought about by proper attention to the electrical continuity of the track by means of the installation of the proper rail-bonds, by a proper regard for the location of feeding stations, and by the judicious use of return cables.

Every pipe system should be considered individually. Conditions may arise within one system which may demand a certain specific method in order to insure protection against electrolytic corrosion. Different conditions may exist in some other pipe system which may be more efficiently protected by the installation of a different [illegible] a combination of a number of system.

Frequent electrical tests should be made on pipe systems in order to determine whether or not they [illegible] proper protection. These examinations should be made at least once a year. If tracks are rearranged, or if new power plants are installed, or the distribution system changed, or additional drainage supplied, electrolytic measurements should be made immediately after such modifications are made.

Ditch Design and Prevention of Silt Deposit

The design of drainage ditches for the prevention of silt deposits and thereby the reduction of maintenance costs is a subject that drainage engineers may devote themselves to with appreciable results. The theory of the deposition of silt in the bottom of a ditch is dependent upon the interrelation of velocity, depth and breadth, and by the proper proportion of these components, silting may be reduced to a minimum if not altogether eliminated, according to Q. C. Ayres, Assistant Professor, Iowa State College, Ames, Iowa, in a paper presented by him before the recent annual meeting of the Iowa Engineering Society. The following notes are abstracted from Prof. Ayres' paper:

The power of a stream which supports silt carried in suspension is derived from the upward component of the velocity of eddies; eddying is aggravated by high velocities and shallow depths, and soothed by low velocities and great depths. It follows, then, that the supporting power or silt carrying capacity of water is likely to vary directly with some function of the velocity and inversely with the depth. Apparently this capacity is independent of width, but such is actually not the case, because the wider a stream is made the greater the number of eddies become having upward velocity components.

The total energy of any flowing stream—which is but another way of expressing capacity to do work or develop power—may be defined as the sum of its potential energy, represented by depth of flow, and its kinetic energy, represented by velocity head $\left(\frac{V^2}{2g}\right)$.

For uniform flow the sum of these values remains constant no matter how much the amount of each may vary between themselves; if we increase depth, we automatically decrease velocity head. By the same token if we decrease depth, we automatically increase velocity head, provided the slope remains constant. Now as silt carrying capacity is largely a function of velocity head, the problem at ditch and grade junctions is to keep the kinetic energy above a certain minimum value by varying the depth of flow. This of course implies increasing ditch width to care for a given discharge. As this minimum value of velocity head or kinetic energy just mentioned is a direct function of velocity, the same principle may be stated in simpler form by reference to some velocity value which is high enough to prevent silting and low enough to avoid erosion. We may designate this particular velocity which varies with the depth but is independent of width the "critical velocity".

In order to avoid silting in any ditch, then, the mean velocity of the stream must not be kept constant throughout, but must be increased with the depth. This means that the common practice of suddenly increasing the depth of ditches to take care of deep tile outlets without providing for an increase in velocity cannot be recommended, as the deeper section, under ordinary conditions, is almost certain to collect large silt deposits.

R. G. Kennedy has proposed a formula expressing the relation between critical velocity and depth as follows:

$$v = cd^m$$

where v and d are the critical velocity and corresponding depth, c and m are constants to be determined by experiment. The author of this formula has made a number of observations on canals of various sizes in India which have been in service for a great length of time and, through a long process of silting and erosion, have finally reached a state of permanent silt equilibrium. From these investigations he deduced numerical values for c and m, namely, $c = 0.84$ and $m = 0.64$, which substituted in the above equation give

$$v = 0.84\, d^{0.64}$$

v being the mean velocity in feet per second and d the depth in feet. The claim is made that this latter formula is applicable to all ditches without regard to variations in size or to the character or specific gravity of silt. This contention is substantiated by E. C. Thrupp, who has shown from observations covering the entire range of velocity depth and silt character, that Kennedy's results are approximately true for all streams. Corresponding values of v in the equation for assumed values of d are here given for convenience in computations:

d =	1	2	3	4	5	6	7	8	9	10
v =	0.84	1.30	1.70	2.04	2.35	2.64	2.92	3.18	3.43	3.66

S. W. Frescoln states: "For any practical ditch section having less than 1.5 ft. fall per mile, Kutter's formula with $n = 0.30$ will give velocities less than the critical velocity, v, corresponding to the depth; or, in other words, for $n = 0.030$, all channels with fall less than about 1.5 ft. per mile are certain to silt somewhat. Hence, for such cases, the only thing to do is to so proportion the channels that the liability to silt will be reduced to a minimum. It can be mathematically shown that for a rectangular channel and a given discharge the cross section that gives the least value to the expression $bd^{1.64}$ will have the least tendency to silt, and therefore this is the relation that should exist between the value of b and d for such cases. In general, this will give a comparatively small depth, but, in the case of large channels, it will not be less than is quite usual in design. For $n = 0.0225$, the limiting slope is about 0.75 ft. per mile."

While it may not always be feasible to apply these principles in practice on account of prohibitive cost, they certainly deserve most careful study in any economical drainage design.

Comparative Costs of Street Cleaning Ash and Garbage Collection and Disposal

In a report submitted last July to the City Council of Philadelphia, by a committee of engineers of that city, consisting of E. B. Morden, Chief of the Bureau of Street Cleaning; James W. Follin, Engineer of the Bureau of Municipal Research; and J. H. Nelson, Principal Assistant Engineer of the Bureau of Highways, a chart was presented summarizing the street cleaning and ash garbage collection work in various cities visited by the committee. Table I is taken from the chart.

TABLE I.—COMPARISON OF MUNICIPAL STATISTICS OF 16 CITIES.

					St. cleaning		Ash & rubbish collection & disposal		Garbage collection & disposal		Activities — St. cleaning, ash & rubbish & garbage collection & disposal	
	Pop.	Area, sq. miles	Pop. per A.	Miles of pvd. Sts.	Cost per capita.	Cost per Mile of paved Sts.	Cost per capita.	Cost per ton.	Cost per capita.	Cost per ton.	Cost per capita.	Cost per sq. mile.
[illegible]	[illegible]	140	[illegible]	1700	..	......	.. ..	.....	.....	....	$2.62	$41,000
Chicago, Ill.	2,701,000	200	211	2112	.	......	.....	.....	.....	.....	1.99	26,400
[illegible]	[illegible]	129	220	1350	$1.58	$2,134	$0.87	$2.59	$0.42	$8.04[1]	2.88	40,700
[illegible]	[illegible]	90	172	[illegible]		......	.....	.....	0.60	5.04	2.32	25,600
[illegible]	[illegible]	61	198	[illegible]	[illegible]	1.110	. .	.	0.10	2.02	1.10[2]	4,300[2]
[illegible]	[illegible]	31	370	[illegible]		.	.....	.....	...	..	.....	......
[illegible]	[illegible]	.		349	[illegible]	1,580	.....	.....	.....	..	2.90	......
[illegible]	[illegible]	41	224	[illegible]	0.97	1,053	.....	6.50	.....	4.60	2.43	22,500
[illegible]	[illegible]	42	[illegible]	430	0.73	868	.....	.....	.....	....	1.96	23,600
[illegible]	[illegible]	62	116	520	0.86	721	.....	.....	.....	.....	2.22	15,600
[illegible]	[illegible]	24	[illegible]	...	...	....	.....	.....	.....	. . .	2.10	37.500
[illegible]	[illegible]	25	181	321	0.64	555	1.20	.....	0.31	4.81	2.32	27.000
Columbus, O.	237,000		160	328	0.77	550	0.48	2.82	0.36	4.60	1.60	16,400
[illegible]	[illegible]	.	14	28	...	.....	. ...	.....	0.12	2 20	.....	......
[illegible]	[illegible]	:	,	[illegible]	....	.....	.....	.....	.....	.....	.....	......
Trenton, N. J.	119,000	[illegible]	200	[illegible]	0.54	902	.....	.....	.....	6.27[3]	1 33	17.500

[1]On basis of 96,000 tons actually collected by contractor, of which about 70,000 tons goes to reduction plant, 26,000 tons to pigs, [illegible] and [illegible] tons are collected by private pig feeders. [2]1918 figures. [3]Includes all mate- [illegible]

Compression and Seepage Tests on Core Material for Hydraulic Fill Dams*

By J. ALBERT HOLMES.

Many investigations have been made to determine the law followed by water in passing through a porous material. The earliest attempt was that of Darcy,† whose conclusion was that the rate of flow is directly proportional to the pressure, or head, and inversely proportional to the thickness of the material. That is, to double the head and keep the depth or thickness of the material the same, would double the flow, and to double the depth or thickness of the material and keep the head the same, would result in one-half the flow. This is known as Darcy's law. He also found that the flow varied with the diameter of the soil grains. The flow also varies with the porosity, which is not dependent on the diameter of the soil grains, but changes with the degree of compactness of the material.† Another important factor is the temperature—viscosity—of the water as it passes through the material.

That the rate of flow is not exactly proportional to the pressure—or head—but increases slightly with the head, resulting in a curve rather than a straight line, has been shown by King and others in a long series of laboratory experiments.** This, however, is a refinement not warranted in ordinary engineering practice.

The investigation of this subject by Mr. Hozen and his reports§ thereon antedate those of Messrs. King and Slichter, and have become classic with American engineers. As a result of his experiments, Mr. Hazen found that the finer 10 per cent of a material has as much effect on seepage rate as the coarser 90 per cent, or, to state it in another manner, the material would have the same seepage rate it has, if the grains were all the same size as those dividing the 10 per cent from the 90 per cent. This size, than which one-tenth is finer and nine-tenths coarser, he calls the "effective size."

Another matter which he found to be important is the degree of uniformity in the sizes of the grains of a material, whether the grains are all of one size or of various sizes. This relation he expresses as a ratio between the size which has 60 per cent finer than itself and that which has 10 per cent finer than itself. This ratio he calls the "uniformity coefficient" and states that the data only justify the application of his formula to material having a uniformity coefficient below 5 and an effective size of grain of from 0.10 to 3.00 mm.

Although it may not be assumed that Mr. Hazen's formula is applicable to flows through the extremely fine materials used in earth dam cores, yet the mechanical determinations of effective size and coefficient of uniformity may be utilized as an index to the suitability of materials.

As the coefficient approaches unity, a material of uniformly sized grains and higher percentage of voids is indicated; as it departs from unity a more dense material, having variously sized grains, is indicated.

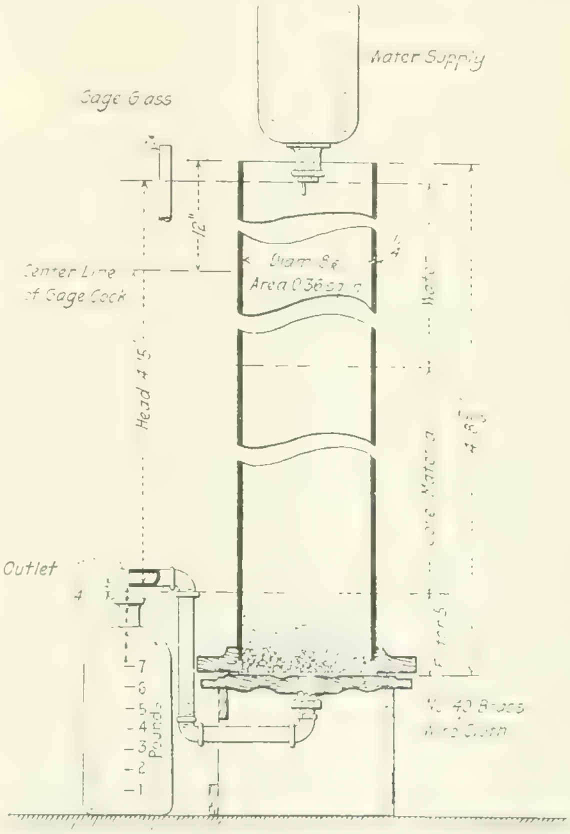
For filters and filtration, a sand having a low uniformity coefficient and a high percentage of voids is required, while for concrete and the core of an earth dam, a dense material is sought.

For an earth dam core such a material is indicated by a low effective size and high uniformity coefficient, but what is still more important to secure imperviousness is the degree of compactness attained in the core itself. Even though a material is dense and fine, it is not impervious when first placed in the core. Until an over-burden has acted to compress a zone, the quantity of water that can pass through that zone is great, but as soon as pressure is applied the resulting compactness is rapid, amounting to 20 per cent under a pressure of only 1 ton per square foot and the reduction in seepage remarkable, being more than 90 per cent.

The methods followed and the formulas derived from the experiments mentioned will not be discussed here, these data are readily accessible and well known to engineers. There is no difficulty in applying these methods, but there is difficulty in eliminating all the disturbing factors encountered in a series of experiments and a feeling, when one is done, that practice has not followed theory as closely as one could wish.

Investigations for Earth Dams of Southern Power Co.—Compression and seepage experiments were made on samples of core material collected from two of the dams. These particular experiments were made to determine the effect of pressure of over-burden on the seepage rate through the material.

At the Paddy Creek Dam of the 442 samples taken and screened, 266, or those containing more than 35 per cent passing the 100-mesh sieve, were put together for making the experiment. The 266 samples were taken from the core on twelve cross-sections, five of them throughout the height of the sections, from bottom to top of dam, and were representative of the entire core.



Test Tank.

The tank in which the test was made consisted of a section of 8-in. wrought-iron pipe about 4 ft. 8 in. long. A blank flange, with gasket, was bolted to a flange screwed to one end of the pipe; this formed the bottom of the tank, the top being open. A ⅝-in. outlet pipe connected at the center of the blank flange led out and up about 6 in. above the inside bottom of the tank and had a short, horizontal, discharge section. At a point 12 in. below the top and directly over the outlet, was a gauge-cock, the glass tube of which extended above the top of the tank. The vertical distance between the invert of the outlet pipe and the water surface in the gauge-glass was the head under which the flow took place and was measured here. A mark on the glass indicated the point at which the water surface should remain and a glance at this showed whether or not the head was being maintained. The tank connections were tested and found to be perfectly tight. On the bottom of the tank, covering the outlet, was a sheet of No. 40 brass-wire cloth and on this was placed 5 in. of gravel and sand filtering material, graded from 1-in. stones at the bottom to sand passing a No. 30 sieve, at the top.

The gravel was washed and the sand was screened and washed and screened a second time, and the varying sizes were placed in layers.

The top of the filtering material was ¼ in. lower than the invert of the short horizontal section of outlet pipe, and this formed a water seal to a point ¼ in. above the filter and excluded air from the open material of the filter. To maintain a uniform head a supply reservoir was placed above the tank. The "reservoir" was a 1-gal. glass bottle, inverted and adjusted at the desired elevation by means of a wooden frame. Passing through the cork in the bottle were two small glass tubes, one extending through the cork from the inside end and down into the water of the tank, the other passing through the cork from the outer or lower end and extending into the bottle.

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*From a paper "Some Investigations and Studies in Hydraulic-Fill Dam Construction," presented Dec. 1 before the American Society of Civil Engineers.

†"Les Fontaines de la Ville de Dijon," par Henri Darcy, Paris, 1856.

**This is demonstrated theoretically by Slichter, 19th Annual Report of the U. S. Geological Survey, Part 11, 1899. See also, Water-Supply and Irrigation Papers No. 67, U. S. Geological Survey, 1902.

‡19th Annual Report of the U. S. Geological Survey, Part 11, 1899.

§"Some Physical Properties of Sands and Gravels, with Special Reference to Their Use in Filtration," by Allen Hazen, Report, Massachusetts State Board of Health, 1892, p. 541.

When the water surface in the tank had fallen slightly below the cork and end of the higher tube, air was admitted to the tube and passed into the bottle, displacing the water, which, at first, flowed down the lower tube and then down both tubes, until another movement of air took place. This was repeated until the head was restored. A very slight drop in head would start the flow from the reservoir.

To prevent evaporation a small neck, small diameter, 1-gal. bottle was used to catch the seepage water. This bottle was "weighted in" on an accurate scale, and the pound points were marked on a strip of paper pasted to the bottle. The pound intervals were divided into tenths, thus permitting accurate readings of weight and volume of flow.

The temperature of the tank water was taken by a thermometer placed in the tank and resting on the sample surface. The thermometer was removed from the water only long enough to make a reading, that is, it was kept almost continuously in the water and directly on the surface of the material being tested. To induce settlement of the sample in the tank a piston and weighted levers were used. The head of the piston had a diameter of ⅜ in. less than that of the tank, and to this head was attached a sheet of cardboard, ¼ in. thick and of diameter slightly less than the tank. Care was taken to keep the piston rod vertical when in use and to see that the head did not jam. In calculating the pressures, the weight of water above the piston head and of the piston itself was added to that induced by the lever and weights.

The material to be tested was placed in the tank in the following manner: The outlet pipe was extended about 5 in. above the top of the filtering material and water was introduced into the tank and upward through the filter to a point 5 in. above it. The tank was then filled to within 1 ft. of the top by lowering water in a small bucket and tipping it out. A part of the fine core material to be tested was then placed in a bucket of water in the proportion of about 1 part to 3 parts of water, thoroughly mixed, and added to the water already in the tank. This was repeated three times, the water for the second and third mixings being taken from the tank and returned to it.

The mixings extended over two days, the material settling during the intervals, the object being to simulate sluicing into the pool of the dam. After the test had been completed and the core material taken from the tank, it was found that the coarser parts had separated somewhat from the finer in the process of placing. It was estimated that the depth in the tank of the sample dry was 1.84 ft., and the percentages of settlement under pressure are based on this depth. The cross sectional area of the tank was 0.36 sq. ft.

The tank was first allowed to stand 9 days with the outlet closed and the tank filled to the top with water. At the end of this period the first measurement of depth of material was made, using a wooden rod to the end of which was attached a sheet of thin metal of slightly less diameter than the inside of the tank, thus covering the whole surface of the material without sinking into it. Following this, the plug was removed from the outlet, and the flow was measured for 7 days by the drop in the tank. The outlet was again plugged and allowed to remain so for 20 days, at the end of which time it was found that the sample had settled 0.151 ft. The plug was then removed and the flow was measured for 5 days. Up to this point in the experiment no pressure other than that due to the water had been applied to the material in the tank.

The seepage rate was high, amounting in 24 hours to several times the capacity of the supply reservoir. This flow was collected in an open bucket and returned to the tank and in this way the evaporation was determined and added to the measured drop to obtain the correct flow. Measurements were taken at 9 a. m. and 9 p. m., to obtain both the day and night flow and temperatures of tank water taken at the same time. Pressure was now applied to the sample by the piston, lever, and weights, the first load so applied amounting to 760 lbs. per square foot. Following each flow period, the load was doubled. During the fifth or last flow period the seepage had become so small that it was measured only once in 24 hours. The measurement was made at 9 p. m. and the temperature of tank water taken at 9 a. m. and 9 p. m.

Whenever increased pressure was applied to the material in the tank an immediate settlement took place, which amounted to a greater part of the settlement induced by pressure. That is, most of the settlement took place quickly under each increased load and then slowly for the remainder of the period. In the dam the load is applied gradually and the core settlement is more uniform. In applying the load of 3,400 lb. per square foot, this intial movement was quite marked.

Pressure and Seepage.—Pressure was maintained under each load until no further movement of the lever could be detected. Measurements were taken at the beginning and end of each flow period to determine whether or not the material in the tank had risen after pressure had been removed and during the flow period. No rise of material occurred during any of the flow periods. The pressure data obtained are given in Table I, the pressures given during settlement and flow periods being those due to the column of water above the sample.

TABLE I.

No. of days.	Period	Pressure in pounds per sq. ft.	Depth of material. in feet.	Total settlement	Percentage of settlement of 1.84 ft.
9	Settlement	150	1,791	.....	..
7	Flow	120	.....	.....	..
20	Settlement	160	1.640	0.151	11
5	Flow	120	1.640	0.151	11
7	Pressure	760	1.505	0.286	18
12	Flow	170	1.505	0.286	18
12	Pressure	1,550	1.476	0.315	20
13	Flow	170	1.476	0.315	20
7	Pressure	3,400	1.411	0.380	23
12	Flow	170	1.411	0.380	23

Using the average flows under the varying pressures of the different periods, the maximum rate or quantity of water that will filter through the material with a loss of head equal to the depth of the sample, given in gallons per acre, is shown in Table II. The quantities have been reduced to a uniform temperature of 50° F.

TABLE II

Pressure, in pounds per square foot.	Seepage, in cubic feet per 24 hrs. on 0.36 sq. ft. with 4.15-ft. head.	Depth of material above outlet in feet.	Seepage, in cu. feet per 24 hrs. on 1 sq. ft., with 4.15-ft. head.	Seepage, in cubic feet per 24 hrs. on 1 sq. ft., with 1:1 slope.	Maximum rate, in gallons per acre per 24 hrs.
150	0.5721	1.770	1.5892	0.6778	220,800
160	0.5138	1.619	1.4272	0.5568	181,400
760	0.1210	1.484	0.3361	0.1202	39,200
1,550	0.0759	1.455	0.2108	0.0739	24,100
3,100	0.0485	1.390	0.1347	0.0451	14,700

Experiment at Linnville Dam of Southern Power Co.—An experiment similar to that described for the Paddy Creek Dam was also made with core material from the Linville Dam. Of the 577 samples taken on five cross-sections, from the bottom of the dam up to 10 ft. below the flow line, 370 contained more than 35 per cent passing the 100-mesh sieve. The 370 core samples were combined to make the test sample.

The same tank was used in this experiment as for the tests on the Paddy Creek Dam material. After placing the filter gravel in the bottom of the tank, water was introduced through the outlet pipe and upward through the filter to a depth of about 1 in. above the gravel.

Following this, the core material was put in the tank dry to avoid the separation that occurred when the Paddy Creek material was placed wet, and the sample was not rammed in the tank. It had a depth of 2.75 ft. in this loose condition.

Through an extension of the outlet pipe, water was again introduced into the tank and passed upward through the loose core material in a very short time, about 25 minutes. Pressure was applied to the sample at once, and the settlement and flow periods, as in the first part of the Paddy Creek dam experiment, were omitted. Under a pressure of 710 lb. per square foot, this material settled 17 per cent; the Paddy Creek Dam material settled 18 per cent under a pressure of 760 lb. per square foot. The settlement data in Table III show a close agreement with the data given for Paddy Creek Dam, in Table I.

TABLE III.

No. of days.	Pressure, in pounds per square foot.	Depth of material in feet.	Total settlement.	Percentage of settlement of 2.75 ft.
11	710	2.281	0.469	17
14	1.470	2.240	0.510	19
11	3.360	2.125	0.625	23

Greater resistance to seepage is encountered by the water at the surface of the sample than lower down, and to remove or reduce this resistance, the surface of the sample was scratched. This was done with a knife and to a depth of about 1 in. The scratching caused a slight increase in depth of the sample and a considerable increase in the seepage rate. To show the effect of the scratching, the quantities were measured both before and after scratching the surface, and the results were not uniform, as may be noted in Table IV. In this table the rates have also been reduced to a uniform temperature of 50° F.

TABLE IV.

Pressure, in pounds per square foot.	Seepage, in cubic feet per 24 hrs. on 0.36 sq. ft., with 4.15-ft. head.	Depth of material above outlet, in feet.	Seepage, in cubic feet per 24 hrs., on 1 sq. ft., with 4.15-ft. head.	Seepage, in cubic feet per 24 hrs., on 1 sq. ft., with 1:1 slope.	Maximum rate in gallons per acre per 24 hrs.
710	0.1514	2.260	0.4205	0.2290	74.600
710	*0.1699	2.281	0.4719	0.2594	†84,500
1,470	0.1191	2.219	0.3308	0.1769	57,000
1,470	*0.1474	2.229	0.4094	0.2199	‡71,600
3,360	0.0835	2.104	0.2319	0.1176	38,200
3,300	*0.1072	2.110	0.2978	0.1514	§49,300

*After scratching surface of sample.
†13% increase.
‡24% increase.
§29% increase.

The second or higher rate obtained in each of these test periods has been plotted on logarithmic paper and the resulting curve extended to greater pressures.

If the pressure exerted by the overlying material at various depths in the dam were known, the corresponding seepage rate could be taken from the curve and the seepage determined for that particular depth and therefore for the full height of the dam. The Goldbeck pressure cells now installed in the Miami Dams are giving the information for those dams. Other valuable information needed is the weight per cubic foot and the percentage of contained water at various depths in the core. These will also be obtained at the Miami Dams by borings in the cores and from test wells in the masonry structures.

To estimate the total seepage through the Linville Dam, without knowing the weight of the material in the core or the depth at which a particular pressure takes place, the rate derived from the test under the highest pressure applied—3,360 lb. per square foot—was used for the entire height of the dam; this gives excess seepage for the lower portions. With water standing for a considerable time at full reservoir, the seepage was estimated to amount to 21 gal. per minute, or 0.047 second foot. This is considering only that portion of the dam containing more than 35 per cent passing a 100-mesh sieve or more than 35 per cent fine.

Similarly, for Paddy Creek Dam the seepage was estimated to amount to about 10 gal. per minute. This, however, was at a higher temperature and without having scratched the surface of the sample in the test tank. Reducing the temperature to 50° F. would lower this estimate and scratching the surface of the sample would have raised it, but probably to an amount less than that estimated for the Linville Dam, if the scratching could have been to exactly the same depth and of the same amount. The scratching introduces a very disturbing element into the problem in that it cannot be done in a uniform manner.

Careful measurements of depth of material were made at the beginning and end of each flow period, and no increase in depth occurred during any period; that is, there was no swelling of the material after pressure had been removed. The sample was found to contain 28.6 per cent of moisture immediately after removal from the tank. It was very compact and was taken out with difficulty, and there was no stratification. This was the condition after a pressure of 11 days under 3,360 lb. per square foot and a continuous flow of 21 days.

Temperature—Viscosity.—Corrections from temperature of tank water, tail-water, or water in the gage-glasses are all unsatisfactory in that they are not the same as that of the water as it passes through the sample. The temperature in the sample changes less rapidly than does the water in the positions mentioned previously. The notes often show a greater flow for a low night temperature than for a higher day temperature. For a rising temperature the correction is too large and for a falling one, it is too small. To obtain results more nearly correct, more elaborate apparatus is necessary, and thermometers should be introduced into the core material through holes drilled in the sides of the tank and fitted with stuffing boxes.

Table V shows how the record, made irregular by temperature changes (Columns 2 and 3) is smoothed out by applying the corrections (Column 4).

TABLE V.

Date, 1919 (1)	Cubic feet per 24 hours on 0.36 sq. ft., with 4.15-ft. head (2)	Temperature of tank water, in degrees, Fahrenheit (3)	Cubic feet per 24 hrs. on 0.36 sq. ft., with 4.15-ft. head, reduced to 50° Fahr. (4)
July 30, day	0.128	85	0.081
July 30-31 night .	0.117	77	0.081
July 31, day	0.128	84	0.082
July 31-Aug. 1, night	0.119	79	0.080
Aug. 1, day . ..	0.128	83	0.083
Aug. 1-2, night	0.119	79	0.080
Aug. 2, day	0.130	82	0.084
Aug. 2-3, night	0.119	75	0.084
Aug. 3, day ..	0.123	78	0.084
Aug. 3-4, night	0.113	70	0.085
Aug. 4, day	0.132	84	0.084
Aug. 4-5, night	0.122	74	0.087
Aug. 5, day .	0.137	86	0.086
Aug. 5-6, night	0.128	77	0.088
Average	....	..	0.835

The experiment on Paddy Creek Dam material was made during September, October, November and December, 1918, and that from Linville Dam during June, July, and August, 1919. In the first experiment, the average temperature ranged from 60° to 66° F., and there was a gradual decrease in the volume of seepage during each flow period. In the second experiment, the temperatures were much higher, and there was an increase in volume of seepage during each flow period. The apparatus was housed. This experiment might well be extended in a laboratory where apparatus for applying greater pressures is available.

Permeability of Clay.—Some interesting experiments have been made by W. Spring on the permeability of clay.*

To determine whether or not clay would give up its moisture under pressure and in the presence of water, a mass containing 33.66 per cent moisture was placed in a porous jar—battery cell—the cell surrounded by water, and the clay subjected to a pressure of about 3 tons per square foot for 3 days. This reduced the moisture content to 26.86 per cent, or 30.33 per cent of the original quantity of water present.

A number of trials, using pastes containing varied quantities up to 70 per cent of water and subjecting each to the same pressure, or 3 tons per square foot, resulted in reducing each sample to about the same degree of hardness and the same moisture content, namely, about 27 per cent. Doubling the pressure, or increasing it to 6 tons per square foot, further reduced the moisture to 23 per cent. Not much pressure is necessary to cause clay to give up its water, and a greater pressure makes a quicker expulsion.

Another question investigated was: Is a clay which is mechanically prevented from expanding still permeable by water?

To test this two porous earthen battery cells were filled with clay. The clay was dried, pulverized, sifted, and carefully tamped into the cells. Covers were bolted to the cells and through the cover of one was passed an open metal tube in which expansion might take place.

Both cells were placed in water, keeping the tube above the surface. The imprisoned clay absorbed only 3.37 per cent of moisture and became very hard, while that in the open cell was soft and absorbed 12.09 per cent, or nearly four times as much.

Other experiments were made with still greater care. Samples were placed in sections of an artery and imprisoned in porous earthenware. The function of the artery was to prevent solids, colloids, or substances dissolved in the water from passing into the sample.

An imprisoned sample of clay absorbed 2.67 per cent of water, while a sample enclosed in an artery only absorbed 15.65 per cent, or six times as much. Loam was found to take up 24.56 per cent when firmly enclosed and 51.80 per cent when free to expand.

In the case of a clay having a specific gravity of 2.62, the increase in volume was found to be almost proportional to the volume of water added. The contraction due to absorption of water amounts to less than 2 parts per 1,000 of the total volume, the conclusion being that, in general, a wet clay expands in proportion to the quantity of water it absorbs. The expansive force of clay in contact with water is estimated to be less than 2 kg. per sq. cm.

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*Spring, W., "Quelques Experiences sur la Permeabilite de Argile." Societe Geolog que de Belgique, Annales, Tome 28, pp. 117-127 (1901).

Weir Formulas on Simplified Assumptions

By MILTON F. STEIN.

In the theoretic derivation of the formulas for the flow of water over weirs, it is assumed that the total flow is equivalent to the sum of that from a series of orifices situated in the plane of the weir notch, of infinitesimal height, width varying with the shape of the weir, and under a head varying from the depth on the weir to zero at the surface. To these imaginary orifices a coefficient C is applied, which is usually taken as 0.60, this being the coefficient of discharge as experimentally determined for orifices under average conditions. These assumptions form a convenient fiction, and are born out by experimental results, which coincidence has caused the resulting formulas to pass current as a true statement of the conditions of flow over a weir.

It is a matter of common observation that the assumptions just mentioned are not borne out by the facts. The head in the plane of the weir notch is not the theoretical head, but considerably less, neither is the velocity at the surface of the water zero, as these assumptions would require, but has a considerable value, and finally there is no reason for assuming that the coefficient C derived for orifices under comparatively high heads, should apply to weirs where the relation of head, area, and wetted perimeter are quite different.

In the following formulas the assumption will be made that the velocity is uniform over the entire area of the weir, although the facts are that it is greater at the bottom than at the surface, and this assumption probably errs as far on one side of the truth as the usual one does on the other. It is further understood that in the weirs considered the end contractions are suppressed.

From the level surface some distance back of the weir to the surface at the weir there is a drop, due to the velocity head required by the flow over the weir, and this will be designated by y. Denoting the area of the weir notch measured up to the water surface as usually taken by A, and the breadth of the notch by b, then

$$\text{Velocity} = V = \frac{Q}{A - by} \quad \text{and velocity head} = y = \frac{Q^2}{2g(A - by)^2}$$

solving for Q,

$$\text{Discharge} = \sqrt{2g}\,(b^2y^3 - 2Aby^2 + A^2y)^{1/2}$$

By the principal of conservation of energy this discharge, Q, will be the maximum that can occur under existing conditions, or the derivative of Q with respect to y must be zero. Performing the indicated steps there is obtained

$$y = \frac{A}{b} \text{ or } \frac{A}{3b}$$

of which the first result is absurd and the second is the one required. Substituting this value in the equation for Q, gives

$$Q = 3.08\sqrt{\frac{A^3}{b}} \qquad \text{(I)}$$

This equation applies to any weir with parallel sides regardless of the contour of the bottom. If the weir be of the usual rectangular form, then $A = bh$, and the formula becomes

$$Q = 3.08\ bh^{3/2} \qquad \text{(II)}$$

This is comparable with the usual theoretical formula, $Q = 3.2\ bh^{3/2}$, and with the empirical formula of Francis, $Q = 3.33\ bh^{3/2}$.

It is to be noted that in this derivation, contrary to the customary one, no experimental constant is introduced, and yet the formula closely approximates the results of experiments. It may be remarked that formula I is the same as the flow in a frictionless channel, which is what a suppressed weir really is. That it gives a discharge slightly below the actual is probably due to the assumption of a uniform velocity throughout, whereas the velocity increases somewhat from the surface downward. By a comparison of the discharge as computed by formulas of the type herein derived appropriate for various form of weirs with the actual discharge of such weirs the [illegible] distribution of velocity could be ascertained.

This method applied to a 60 degree V notch gives the formula $Q = 1.14\ h^{5/2}$ as against the experimental formula, $Q = 1.18\ h^{5/2}$.

The real point to emphasize is that engineering formulas deduced from theory on certain assumptions very often do not give the correct conception of the processes to which they are intended to apply, even though experiment seems to bear them out. Often the general acceptance of such formulas leads to a cessation of analytical investigation, and consequently of true scientific progress.

A $300,000,000 Irrigation Project

A single project estimated to cost $300,000,000 for the irrigation of 1,753,000 acres of land in the Columbia River Baisin, Washington, is proposed in the recently issued report of the Columbian Baisin Survey Commission, of which Marvin Chase, Washington State Highway Engineer, is chairman. Under the plans outlined water would be stored in one state, diverted from its natural channel in a second, and delivered for irrigation in a third. From the point of storage to that of use the irrigation water would be conveyed over 200 miles in natural channels and 130 in an artificial supply main, with branch mains aggregating 1,000 miles. The main canal would have a capacity of 20,000 second-feet, eight or ten times that of the largest irrigation canals built by the U. S. Reclamation Service to date.

Water control would begin with storage in Flathead Lake, Mont. Thence the stored water would course the Flathead River and the Clark's Fork of the Columbia, joining with runoff entering Pend Oreille Lake, Idaho. Below the latter a dam at Albany Falls, would serve to provide additional storage in the Lake and to divert the irrigation flow into the head of the artificial supply main. This would be in tunnel for about 5 miles, emerging near Penrith, Wash., to utilize the Little Spokane River, canalized for the purpose, as a channel to Chain Lakes, which would be raised by the Camden Dam. Southward from Camden to Spokane the aqueduct would alternate between open channel and tunnel—the Milan, Deep Creek, Deadman Creek, and Pleasant Prairie Tunnels. The open channels would include lakes formed by dams at Dry, Deep, and Deadman Creeks. The Spokane River crossing would be made just east of the city. Thence an open channel and the Manito Tunnel would deliver the water to Latah Creek, where another dam would be required. From Latah Creek Lake the flow would enter Bonnie Lake Tunnel, the longest of the system, between 15 and 16 miles. This would deliver to Rock Creek, and a dam at the outlet of Rock Lake would form an enlarged basin from which the water would be carried mainly in open channel to the end of the supply main at Hillcrest, about 10 miles southeast of Ritzville.

In addition to those named above, smaller dams are proposed at several points on the main canal and distributaries. Six of these are proposed to care for overflow from wasteways on the project and may be designed to provide also for secondary storage. In all, 20 dams are listed in the report. These at Flathead and Pend Oreille Lakes are to be of concrete, the others of earth and rock fills. The structures would vary in length from 450 to 6,800 feet, in height from 28 to 180 ft., would aggregate over 25,000,000 yards.

Thirteen tunnels are proposed on the distributaries, making 21 in all. These aggregate about 80 miles of single bore and are estimated by the commission to cost $119,000,000. The tunnels on the supply main would be twin bores, 33 ft. 5 in. diameter, except the Bonnie Lake Tunnel, on which the bores would be 31 ft. 4 in. It is proposed to line tunnels and canals with concrete.

Other construction features include 33 inverted siphons, estimated to cost $34,800,000; 19 railroad underpasses, and a larger number of spillways, wasteways, and other miscellaneous structures. The total estimated cost for the Pend Oreille maximum development is summarized as follows:

Flathead Reservoir	$ 2,090,933
Pend Oreille Reservoir	1,194,368
Albany Falls headgates	440,841
Newport Tunnel	18,394,255
Canal Newport Tunnel to Chain Lakes	2,370,290
Canal Chain Lakes to Hillcrest	25,191,161
Camden Dam	1,437,788
Dry Creek Dam	1,149,905
Milan Tunnel	8,568,410
Deep Creek Tunnel	3,856,821
Deep Creek Dam	731,807
Deadman Creek Tunnel	5,396,817
Deadman Creek Dam	3,804,747
Pleasant Prairie Tunnel	10,083,948
Spokane River Crossing	1,267,539
Manito Tunnel	10,628,080

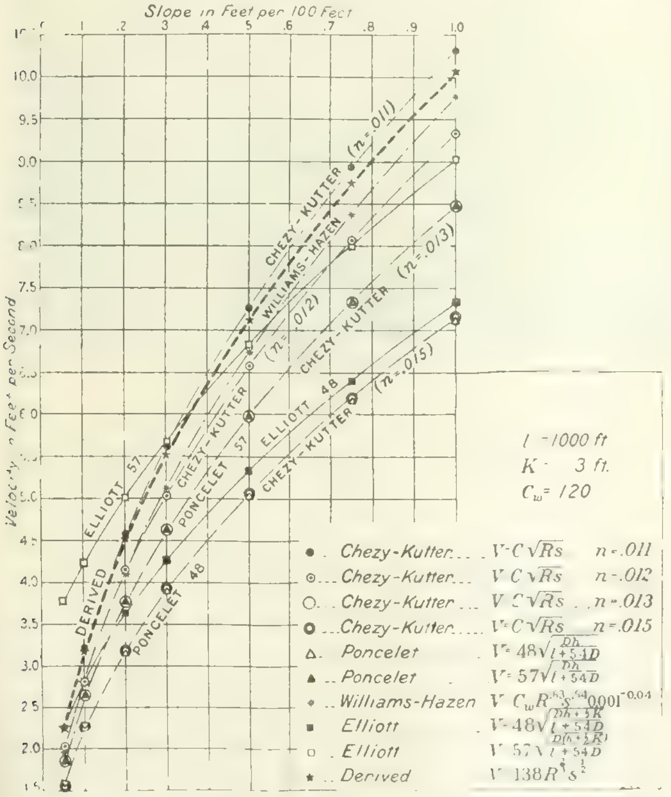
Latah Creek Dam	2,487,751
Bonnie Lake Tunnel	46,081,166
Rock Lake Dam	[illegible]
Wassun Creek inverted siphon	[illegible]
Dragoon Lake Dam	17,659
McCall Dam and Dike	401,402
Patterson Tunnel	[illegible]
Cowy Creek inverted siphon	[illegible]
Hillcrest inverted siphon and gates	[illegible]
Fences, Albany Falls to Hillcrest	106,200
Telephone lines, Albany Falls to Hillcrest	91,200
Distribution, North Division	*57,461,163
Distribution, Central Division	*23,160,325
Distribution, South Division	*26,646,606
Distribution Lateral "MI"	[illegible]
Distribution system below 100 second-feet capacity	26,295,000
Spillways and wasteways	3,027,345
Lateral headgates	403,213
Railroad and highway changes and crossings	[illegible]
General incidentals, miscellaneous items, including patrol houses	[illegible]
General engineering, administration and legal expenses preceding construction	[illegible]
Administration, legal and general expense during construction	2,800,000
Total cost maximum development	[illegible]

*Does not include highway changes, which are grouped under "Railroad and highway changes and crossings."

Determination of Kutter's Coefficient for 30 in. Concrete Tile

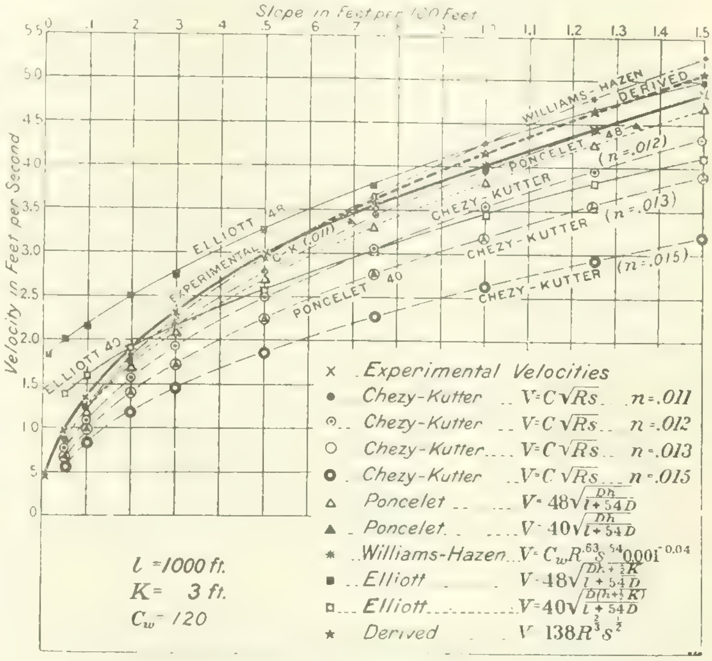
During the past year experiments have been made on a 30-in. concrete tile for the purpose of determining Kutter's n and comparing it with data secured at Arlington, Va., on small tile. The results of experiments on small tile are contained in Bulletin 854, U. S. Department of Agriculture, and were reviewed in the Oct. 13 issue of Engineering and Contracting. The tests on the 30-in. tile were made by C. E. Ramser, Senior Drainage Engineer, Bureau of Public Roads, in Judicial Drain No. 15, Murray County, Minnesota, and the results are given in a paper presented last month by D. L. Yarnell, Senior Drainage Engineer, U. S. Bureau of Public Roads, at the 33rd annual meeting of the Iowa Engineering Society, from which the following information is taken.

The measurements of the hydraulic slope and the depth of flow were made at two surface inlets, one 1,224 ft. above the tile outlet and the other 1,237 ft. above the tile outlet. The tile were laid at a grade of .1 per cent. In tests 1 to 4 inclusive the tile were under pressure at the upper surface inlet. It will be noted that the values of n, for the tile under pressure, ranged from .0122 to 0.133. The value of n for the tile nearly full, but not under pressure, was found to be .01185. The coefficient of roughness increased with the decrease in the depth of flow, which fact was brought out also by the tests conducted at the Arlington plant. No facilities were available for conducting tests of tile under pressure at Arlington, therefore it was not possible to determine whether the coefficient of roughness for tile flowing under pressure would be greater than for tile flowing just full.



Comparison of Velocities Computed by Various Formulas Applied to 30 In. Drain Tile Flowing Full.

In order to compare the velocities as obtained from various formulas for a given size of tile for different grades, two charts have been compiled for 8-in. and 30-in. tile, respectively. Velocity curves have been drawn using as co-ordinates the velocity in feet per second and the slope in feet per 100 ft. These curves are worthy of careful study. From the values obtained by experiment as shown in Bulletin 854 it would appear that the velocities computed by using the derived formula would approximate closely those obtained by applying the Chezy-Kutter formula with a value of n of .011. This is not strictly correct. On the chart for the 8-in. tile it will be noted that the velocities computed from the derived formula are greater than those computed from the Chezy-Kutter equation, the differences ranging from .1 to 0.32 ft. per second. For the 30-in. tile, the reverse is true; that is, the velocities as computed from the derived formula are less than those computed from the Chezy-Kutter formula. The differences range from .01 to .31 ft. per second.



Comparison of Velocities Compiled by Various Formulas Applied to 8 In. Drain Tile Flowing Full.

C. G. Elliott in his book, Engineering for Land Drainage, third edition, page 102 (John Wiley & Sons, 1919), suggests using a variable coefficient in the Poncelet formula, this variable depending upon the diameter of the tile. Instead of the value 48 as ordinarily used, he gives a number of values ranging from 34 for 5-in. tile to 64 for 48-in. tile. He also suggests using this variable in the modification of Poncelet's formula. In the chart prepared for the 8-in. tile it will be noted that the curve for the Chezy-Kutter equation, using a value of n of .013, practically coincides with the curve for

ELEMENTS OF EXPERIMENTS ON 30-IN. CONCRETE TILE, JUDICIAL DRAIN NO. 15, MURRAY COUNTY, MINN.

1. Test No.	2. Depth of flow (d), ft.	3. d/D.	4. Area of flow (a), sq. ft.	5. a/A	6. Hydraulic radius (R), ft.	7. Discharge (Q), cu. ft. per sec.	8. Velocity (V), ft. per sec.	9. Slope (s).	10. Kutter coefficient (n).	11. Chezy coefficient (C).
1	2.50	1.00	4.91	1.00	0.625	29.96	6.10	.00551	.0133	103.9
2	2.48	.99	4.90	.99	.638	23.00	4.69	.00257	.0122	115.8
3	2.48	.99	4.90	.99	.638	21.21	4.33	.00239	.0126	110.9
4	2.45	.98	4.87	.99	.666	20.16	4.14	.00210	.0126	110.7
5	2.26	.90	4.58	.93	[illegible]	17.11	3.73	.001345	.01185	121.3
6	1.92	.77	4.03	.82	.753	13.44	3.33	.001126	.0126	115.0
7	1.59	.64	3.28	[illegible]	.713	9.74	2.97	.001017	.0127	110.3
8	1.31	.52	2.60	.53	[illegible]	6.56	2.52	.000966	.0135	101.3
9	1.21	.48	2.35	.48	.610	4.95	2.11	.000966	.0154	86.9
10	0.74	.29	1.22	.25	.420	1.63	1.34	.000976	.0178	66.1
11	0.67	.27	1.06	.22	.388	1.31	1.24	.000966	.0186	60.1

the Poncelet formula using a value of 40 recommended for this size of tile. The curves for the other formulas applied to an 8-in. tile are also shown. In the chart for the 30-in. tile, the curve for the Poncelet formula, using a value of 48, coincides with the curve for the Chezy-Kutter equation with a value of n of .015. The curve for the Poncelet formula using a value of 57 coincides with the curve for the Chezy-Kutter equation using a value of n of .013. None of the curves for the other formulas coincide, as may be seen from a study of the chart.

During the past year the writer interviewd a great many drainage engineers in Minnesota and he found that for computing flow in tile they used almost exclusively the Chezy-Kutter formula with a coefficient of roughness of either .013 or .015. The tests conducted at Arlington would indicate that the value of n for drain tile lies between .011 and .012. Mr. Ramser's experiments which comprise the only known existing data on large sizes of tile show a value of approximately .012 for tile flowing full. It is desirable that further experimental data be secured on the larger sizes of drain tile, both to determine the coefficient of roughness and to check the accuracy of the derived formula.

To the engineer who desires to use the derived formula it is suggested that he make a comparison of discharge capacities obtained from it with capacities computed from the formula he has been using. To the engineer who prefers the Chezy-Kutter equation a value of n of .012 is suggested.

Trailer With Dump Body for Garbage and Refuse

A combination of trailer and 2-way side dump body designed to meet the conditions pertaining to ash, rubbish and garbage removal in municipalities, has been placed on the market by the Warner Manufacturing Co., Beloit, Wis. The outstanding features claimed for this outfit are: Interchangeability of the trailer equipment with other bodies for other uses; simple construction in both trailer and body; possibility of operating trailer and turning it around in narrow alleys; simple body construction, assuring complete discharge of the load; loading edge from ground, 2½-yard body, 59 in., 3½-yard body, 62 in.; when body is dumped, the lower edge of body clears the dumpage; body is under constant control of cables, thereby eliminating the jumping off of the body from the trailer; quick operation, as it takes only 50 seconds to raise the body to complete dumping position and after dumping, the body returns to its horizontal position by gravity; light weight of the entire outfit.

Combined Trailer and 2-Way Side Dump Body.

Dewatering Activated Sludge With Basco Ter Meer Machine

Tests at Milwaukee with a centrifugal sludge drying machine have produced a sludge of 79 to 85 per cent moisture, according to data given in a paper presented by George G. Nasmith, C. M. G., before the recent General Professional meeting of the Engineering Institute of Canada, from which the following notes are taken.

The centrifugal is of the Basco Ter Meer type, a German make, and was imported for test purposes at Milwaukee. The machine promises to be more suitable for dewatering Milwaukee activated sludge than sludge presses. The machine is almost automatic in operation, occupies 15 minutes for each cycle, and will centrifuge from 2,000 to 4,000 gallons of sludge per hour. It takes a sludge containing 98.5 per cent moisture and reduces the moisture to from 79 to 85 per cent. The machine runs at about 1200 r.p.m. About 20 per cent of the solids of the sludge pass over in the filtrate and what is to be done with these is still a matter of experimentation.

Personals

Samuel H. Garvin has been appointed city engineer of Bowling Green, Ky.

Allen J. Saville has been appointed commissioner of public works of Richmond, Va.

W. J. Kelly has resigned as County Engineer for Walker County, Texas, to take up similar work in Trinity County, Texas.

C. J. Yorath, City Commissioner of Saskatoon, Sask., has been appointed commissioner of public works and utilities at Edmonton, Alberta.

Burr H. Simpson, who for the past several years has been connected with the Portland Cement Association as field engineer, has resigned to accept a position as sales engineer for West Virginia for the Kentucky Rock Asphalt Co. of Louisville, Kentucky. Mr. Simpson will make his headquarters at Buckhannon, W. Va.

Otto E. Eckert, city engineer of Lansing, Mich., has been elected president of the Michigan Engineering Society. Other officers elected Jan. 28 at the annual meeting were: Vice president, L. N. Hayden, assistant chief engineer of the Detroit United Railway; treasurer, Harry Shuptrine, county bridge engineer, Detroit; secretary, C. B. Huff.

Obituaries

Jerry O'Shaughnessy, superintendent of water works of Columbus, O., died Jan. 28 at his home in that city. He was born in Delaware in 1853, and had been connected with the city water department for nearly 50 years. He began as a laborer in the construction of the first water works plant, and progressed through various grades as wiper, fireman and engineer until he was appointed superintendent of water works by Mayor Cotton Allen in 1896.

Industrial Notes

The Combustion Engineering Corporation, New York City, has opened a branch office at 521 Candler Bldg., Atlanta, Ga., in charge of A. A. Hutchinson.

G. J. Lenher, president of Lenher Engineering Co., New York, who assumed the general management of S. Flory Mfg. Co., Bangor, Pa., upon the death of Samuel Flory, has been elected president of S. Flory Mfg. Co., and will direct its affairs from the home office at Bangor.

Joel A. Thayer, for the past 13 years Superintendent of Streets of the city of Taunton, Mass., has resigned to become the New England manager of the Acme Road Machinery Co. of Frankfort, N. Y. He assumed the management of the Boston office at 141 Milk St., succeeding the late Wm. T. Becker, who had filled this position for many years past, and whose death occurred very suddenly on Dec. 3.

The Austin Machinery Corporation of Louisiana has been incorporated under the laws of that state, to act as sales distributors for Louisiana, Arkansas, Mississippi and Tennessee, of the products of the Austin Machinery Corporation, manufacturers of contractors' equipment. The corporation will carry a full stock of machinery and spare parts for this territory. The general offices are at 1020 Maison Blanche Bldg., New Orleans, La.

E. D. Kellogg has recently been appointed New Jersey representative for the Conveyors' Corporation of America—formerly American Steam Conveyor Corporation—manufacturers of machinery for handling coal, sand, gravel, ashes and other loose bulky materials. He will handle "The American Trolley Carrier" and "The American Steam Jet Conveyor" in the northern half of the state, but will make his headquarters at the eastern office, 110 West 40th St., New York.

Railways and Excavation Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Index of E. & C. Now Ready

The index for Vol. LIV covering the July-December issues of Engineering and Contracting is now ready for distribution. Subscribers desiring a copy should notify us at once. Those who received the indexes for the previous volumes have been listed and need not notify us again.

How Texas Can Get More Railways

Texas, an empire in extent and with an enormous acreage of fertile but undeveloped land, needs thousands of miles of new railways annually for a generation to come. Last year this great state got a scant 55 miles of new railway lines. The people of Texas want capital to flow into their state. They talk glowingly, and truthfully, of the opportunities for splendid return upon agricultural investments. "This state alone can raise enough food and cotton to supply all America and most of Europe," said a Texas farmer the other day to the editor. "What we need most is money," he added apologetically.

"You don't need money most," the editor replied. "Money quickly goes where profits are in sight. What you need most is liberality in your treatment of investors in railways and public utilities."

The farmer looked his surprise. It had never occurred to him that such investors were not liberally treated. He did not know that the Railroad Commission which he had helped elect was regarded by many investors as unreasonably restrictive, and that Texas had long been regarded by most railway officials as being a bad state in which to do business.

Conversation with such farmers has convinced the editor that if a majority of them could be reached by word of mouth, it would not be long before they would demand not merely fair but liberal treatment of investors in railway securities. As it is politicians are apt to think that it is popular to hold down profits on railways to as low a limit as will pass muster before a Federal court as not being confiscatory. But if politicians could hear from their constituents after those constituents had themselves heard both sides of the story relative to railway profits, there would be an end of railway baiting.

At meetings of state granges, of chambers of commerce and of editors and publishers, civil engineers acquainted with railway and utility financing should begin to show the public the folly of any policy that makes it more profitable for the average investor to place his funds in mortgages than in railway stocks. Consider right now the absurdity of asking a railway investor to buy an 8 per cent stock, when mortgages yield 8 per cent. The average business man or farmer expects to make fully 12 to 15 per cent annually on his invested capital. We have yet to find one such investor who would contend against preventing a railway investor from receiving 10 per cent. But, on the other hand, we have to hear of a single rate making commission that has allowed a "fair return" of more than 8 per cent as an average. Occasional instances occur where slightly more than 8 per cent is allowed for a short time, but these are but scattered stars in a very dark night.

The End of the Panic of 1920

That much overworked objective, "psychological", is doing three shifts daily in editorial comments on the causes of industrial depression. Thus: "The depression which now exists is chiefly psychological. It is a state of mind." And having thus diagnosed the disease, the editor proceeds to give the patient an "absent treatment", consisting mostly of absence of common sense.

Without doubt the present depression was made severe because many business men became unduly alarmed. But it is absurd to argue that there was no real cause for alarm. Commodity prices had reached an unprecedented height last May, averaging then two and three quarter times as high as the pre-war average. Many business men had begun to worry over prices long before the "peak" was reached. Bankers in particular had grown uneasy, for they were "holding the bag". They began to curtail credits, and, when they did, the end of the price boom was in sight. Was their anxiety about prices purely mind made? Scarcely. They knew that, in a general way, commodity prices in the past had shown a quantitative relation to the amount of money in circulation. In five years our per capita currency had increased nearly 70 per cent, whereas average commodity prices had risen more than 170 per cent. If there was any truth whatever in the "quantity theory of money and prices", it was apparent that prices had far outrun money, and that a fall was imminent. Now this relationship between money and prices was a physical and not a psychological fact. Other physical facts also worried many business men, such, for example, as the inability of foreign nations to pay for what they had bought. Indeed, there was quite a mob of disquieting facts staring bankers and business men in the face. When the cumulative effect of these physical things became sufficient, there was a sudden collapse of courage, and the "panic of 1920" was on. As in the case of all panics, men went to extremes and made matters worse than they need have been.

Panics are psychological tempests, but they are invariably started by physical forces. It is incorrect therefore, to speak of an industrial crisis as if it were purely psychological. Nor can a business depression be ended merely by pointing out that the country is intrinsically as rich as ever. Business men are not concerned about the existence of abundance of capital that they regard beyond their reach. Their main concern is about the profits of the near future. Hence when prices are crashing, business men refuse to commit themselves for new consignments.

Within the next few weeks the average price of wholesale commodities will have fallen to a level 70 per cent above the pre-war level, and will then, for the first time in six years, be on a parity with the increase in per capita currency in circulation. This will mark the close of the "panic of 1920".

Only 314 Miles of New Railway Line in America in 1920

Civil engineers first came into great prominence in this country as designers of "Clinton's Ditch", the Erie Canal. Shortly after the public recognized the value of applied science when civil engineers ushered in the age of railways. The "railway age" has now entered its second century, but not as auspiciously as it began. During 1920 only 314 miles of first track and 90 miles of other track were built, and this in a country that still offers unbounded possibilities for development. If such a miserably poor showing had been the result of the war, or of "hard times", it would not occasion much comment. But the fact is that it is merely the climax to a decade of progressive stagnation in railway development.

To any engineer who has closely followed the effects of public regulation of railway rates, the main reason for railway stagnation is apparent. For fifteen years many state public service commissions and the interstate commerce commission have been "protecting the public" so vigorously that investors in railway stock have been growing progressively more wary. Like the hunting dog that has been filled with bird shot the average investor needs get but one charge to remain "gun shy" for ever afterward. A new crop of inexperienced investors is harvested each year, and for this reason, and this only, has it been possible to sell new issues of railway stock for many years past. Gradually, however, even this source of capital has been going dry, for the warning cry of the unfortunates has grown louder as their number has increased. Railway financing has at least reached such a pass that only bonds and notes can be sold in considerable quantities. No one wants stock in enterprises that are held down to a "fair return-rate" of only 6 per cent, for if thus held down in the case of successful enterprises it is a certainty that the average return will be less than 6 per cent when the unsuccessful are averaged with the successful.

Six months ago railway rates were raised 25 to 30 per cent, and there was general approbation of the act. But, even so, the annual net earnings of the railways are now averaging less than 3.5 per cent on their book value. To add to the gloom, the public utility commissions of several large states have refused to grant the same percentage of increase in rates granted by the Interstate Commerce Commission, showing that the old policy of "protecting the public" regardless of the effect upon investors still dominates the minds of some rate regulating commissions.

Then, too, there are several state legislative bodies that are investigating the acts of public utility commissioners who have been courageous enough to raise the rates of public utilities. Thus the California Commission has been under fire, although the average increase in public utility rates in California has been only 40 per cent in the last six years!

Fortunately signs are not wanting that show the beginning of a realization that investors cannot be induced to invest in stock whose maximum yield is limited but whose minimum yield is without guarantee. Some leading newspapers are advocating more liberal treatment of railways and other public utilities. A few newspapers are actually praising public utility commissioners for their courage and fairness in raising rates. These are welcome signs, but they are altogether too infrequent as yet to raise any great hope of a speedy conversion of the average investor to the belief that he may safely buy the new stock of railway companies.

What part American civil engineers should take in educating the public to a better understanding of railway finances we shall not center upon now. It seems clear, however, that civil engineering societies should begin to discuss this phase of their duty to the public.

Book Reviews

A Text Book of Geology—Part I—Physical Geology.—By Louis V. Pirsson, late Professor of Physical Geology in the Sheffield Scientific School of Yale University. Second edition. 470 pp. John Wiley & Sons, New York. $3.

This volume forms the first part of a treatise of which "Part II, Historical Geology" is by Charles Schuchert, Professor of Paleontology in Yale University and of Historical Geology in the Scheffield Scientific School.

This book exemplifies a task intelligently undertaken and successfully accomplished. It presents, as the author intended it should, a broad view of the entire subject of physical geology suited to the needs of the general reader or of the student—whether he be seeking only a fair fund of general knowledge or is laying the foundation for detailed studies in one or more of the special fields of the broader science. The more important of these fields, as classified by Prof. Pirsson in his introduction are—Mineralogy, Petrology, Meteorology, Paleontology, Physiography, and Economic Geology.

The accumulation of new knowledge since the finishing of the original work in 1914 is given in the preface as the reason for another edition; and at another place, as if he feared that the inference from the prefatory statement might be overlooked, the author introduces the enticing remark that "much also remains to be done" in the field of geological exploration and deduction.

The eye of the mining engineer will at once be caught by the title of the last chapter—"Ore Deposits"; while elsewhere there is treatment of the many phases of structural geology which at times become matters of engineering concern.

The text is profusely illustrated with line drawings and half tones, and is supplied with an extensive index. It is arranged in two main divisions—Dynamical Geology and Structural Geology. Under the first of these the chapter headings are as follows: I, General Considerations; Work of the Atmosphere; II, Rain and Running Water; III, Lakes and Interior Drainage; IV, The Ocean and Its Work; V, Ice As a Geological Agency; VI, Underground Water; VII, The Geological Work of Organic Life; VIII, Igneous Agencies; Volcanoes and Hot Springs; IX, Movements of the Earth's Outer Shell; Earthquakes. The remaining chapters appear under Structural Geology, and are X, General Structure and Properties of the Earth; XI, Sedimentary Rocks; XII, Igneous Rocks; XIII, Metamorphis Rocks; XIV, Fractures and Faulting of Rocks; XV, Mountain Ranges; Their Origin and History; XVI, Ore Deposits; Appendix—Minerals Important Geologically in Rocks and Ores.

Financial Engineering.—By O. B. Goldman, Consulting Engineer, Professor of Heat Engineering, The Oregon State Agricultural College. 271 pp. John Wiley & Sons, New York. $3.50.

To supply "the need of a correct method of determining the financial efficiency of undertakings, not merely as a whole, but element by element, so that all losses might be discovered, and so that the size and design for best economy might be determined" is the prefatory statement of the purpose of this book.

Of its 8 chapters and 271 pages, 3 chapters comprising the first 58 pages, are devoted to a consideration of the general economic laws and principles applicable to such subjects as Cost Analysis, Value, Rate Base, Fixed Charges and Operating Expenses, Depreciation, Economic Comparison of Permanent and Temporary Installations, etc.

Chapter IV deals chiefly with costs and cost formulas; the references being in the main for the period prior to 1912. Costs per horse power or other unit are given in tabular form for a considerable variety of equipment. There are also tables of steam consumption, boiler efficiency, etc. A number of diagrams are introduced, and some operating costs are given.

Chapter V is devoted to the subject of "vestances"—vestance being defined as "the equivalent cost of a permanent service", and being used as a basis of comparison.

Chapter VI is entitled "Unit Cost Determination", and treats largely of the economics of variable loads. Chapters VII and VIII respectively relate to the determination of the most economic size of systems and most economic type and size of units. Among the subjects treated in these chapters are total production costs and the requirement of stand-by units.

The deduction of all formulas is given in detail. Calculus is used sparingly.

How to Make and Use Graphic Charts. By Allan C. Haskell. Principal Assistant Engineer, Construction Service Co.; with an introduction by Richard T. Dana; New York. Codex Book Co., 1919; 540 pp.; diagrams, 6x9 in.; cloth; $5.

This book is very largely a compilation of material which has appeared from time to time in engineering periodicals and in the proceedings of technical societies. Its object is to call attention to the many ways in which graphic charts may be used, not only to show things more vividly but to shorten the labor in connection with so many problems of every conceivable sort.

The theory and construction of the various methods are described and explained and many examples given. The author reassuringly states, however, that, notwithstanding the fact that the ultimate theory of charts is mathematical, once a person has he properly ruled paper, most of the work done with charts may be accomplished without knowledge of the true mathematical inwardness, thus making it true that with a chart "mathematical work may be done without mathematics." Valuable bibliographies are given with many of the chapters.

Do the Electric Railways Need Any More Technical Graduates?

At this time of the year the prospective five thousand graduates, more or less, of a hundred technical schools are beginning to wonder what they are going to do after commencement. Already the manufacturing and some other industries are planning to send representatives to the colleges to explain to the young men, and young women, too, in some cases, the attractions of their several fields of activity. The electric railways will not be so represented. This is partly because there is no central organization for the electric railways which takes up matters of this kind, and individual railways do not need enough men to warrant them in going to the expense of sending "scouts" to the colleges. It is doubtful, also, if the value of a technical education applied to the right kind of an individual is appreciated as much by the railways as in manufacturing. Possibly the value is actually higher in the latter field, but this ought not to be so.

At any rate, the manufacturers and a few others will get the choice of the educational crop and the railways will take what is left, including, however, those young men who have heard the "call of the rail" and will insist on going into transportation work in spite of lack of invitation and even, if necessary, of opposition. Luckily, this number is considerable.

There are many excellent opportunities for technical graduates in the electric railway and related fields. The whole business is founded upon civil, mechanical and electrical engineering. Of course, the focus of interest has shifted somewhat in recent years from track, power plant and line to fares, schedules, accident reduction, etc. But fundamentally transportation is a proposition of moving people and goods from one point to another with a maximum of speed, economy and safety. As long as this is so the business will need engineers.

Furthermore, the principles underlying engineering have application far outside the engineering divisions of the field and engineers are making themselves useful in the transportation, purchasing, accounting and other departments. They are especially useful in the making of appraisals, either in the railway organization or without, a phase of the work which is bound to become more and more important.

It is too bad that some systematic way has not been provided by which the electric railway field can be explained to engineering students. Some schools have courses in transportation engineering, which serve an excellent purpose, but they need to be supplemented by talks from competent railway executives or their representatives. This would seem to be a line of work for the American Electric Railway Association and American Railway Association to take up on behalf of their respective clienteles.—Editorial in Electric Railway Journal.

Blasting Plastic Clays

The method of blasting ordinary plastic clays for making tile and common brick will depend on the height of the face, the method of digging, the hardness of the clay and the nature of the floor.

In developing this type of blasting, several unexpected results have been obtained. Some pits employing hand digging were having much trouble in mixing the top and bottom strata and were losing trade thereby. Blasting down the face resulted not only in decreasing the cost of digging, but gave a better mixture of the clay than had been possible by the former methods.

In other pits loose boulders seriously retarded the work. Blasting not only loosened the hard clay, but materially assisted in getting out the boulders, and sending the clay to the plant in better shape.

Much good can be done in tempering some clays by blasting the impacted pits, when in a dry condition, well in advance of the need. This permits the absorption of rain, lets the frost in deeper, and begins the processes of tempering that are later finished in the mixer or pug.

Clay is often found over quicksand or other soft ground where difficulty is experienced in the upkeep of tracks for cars or of roads for carts. Digging from above will largely overcome these troubles, as the cars or carts can then be handled on the surface instead of in the bottom of the pit. This substitution is made possible by drag-line or similar excavating rigs that work from above. When the clay is wet or soft, there is no difficulty in filling the buckets and working to full capacity. When the ground is hardened by drying out or freezing, it can be loosened by blasting. Practical pit trials have proved the advantages of this method of digging. Even where the bottom is solid and is free from standing water this method is proving satisfactory. Where the drainage conditions are bad it is to be highly recommended.

When frozen or dried hard, this bank can be shot down by blasts so as to reduce the cost of shoveling. If blasted. a drag-line or steam shovel can be used to replace the hand labor.

Some high-grade clays contain hard pebbles and must be spaded thin to expose the pebbles so that they can be picked out by hand. When this is necessary, blasting should not be practiced unless the clay is dry or frozen and the cut cannot be begun.

To start the work put down two or more shallow holes spaced 30 or 40 in. apart, load each with from one to two cartridges of 30 to 60 per cent ammonia dynamite, primed electrically, and fire all together. This will open up a short trench and expose ample room for the shovelers.

Annual Meeting of Illinois Section Am. W. W. Assoc.—The annual meeting of the Illinois Section of the American Waterworks Association will be held in Chicago, March 23-24. The program and exact place of meeting will be announced later. G. C. Habermeyer, Urbana, Ill., is Secretary.

Costs of Concrete, and Organization Employed on the Taylorsville Works of Miami Conservancy District

The data forming the basis of this article were furnished chiefly by Mr. O. N. Floyd, Division Engineer at Vandalia, Ohio. Other data and descriptive matter are taken from the January issue of The Miami Conservancy Bulletin.

General Description.—The magnitude of this work, and the efficiency with which it has been carried out make it a subject of particular interest and one worthy of detailed study. The outlet works, of which description and costs follow, are shown in general view in Fig. 1. They contain 45,000 cu. yd. of concrete, more than half of which is below the water level in the picture. The extreme width of the structure is 241 ft., its length 628 ft., and its height 111 ft. The base of the right-hand wall is 50 ft. in thickness exclusive of the projecting cut-off wall. Fig. 2 gives the general plan and section of the outlet, and Fig. 3 the completed layout of dam, outlet construction works and gravel pits. There is yet to be constructed a massive cross dam or spillway weir at the location shown in Fig. 3. This structure will contain about 10,000 cu. yd. of concrete. The National Highway will cross both the outlet works and the spillway by pier supported bridges.

The four openings of the outlet works as shown in Fig. 2 will take the entire flood flow of the Miami River, which at spillway level is 53,600 second feet. It is not expected, however, that water will ever go over the spillway; while to top the dam itself would take a flood more than double that of 1913. The reduction in flood flow at Taylorsville could have been made considerably more but for the fact that the cities of Troy and Tippecanoe on the edge of the retarding basin would have required excessive protection.

Work Done by Force Account.—The common inefficiency force account work was in this instance overcome by the employment of a particularly able construction manager. Mr. C. H. Locher, a contractor of long experience, was chosen for the position, and it appears that the action has been justified by the results secured.

Figure 4 shows that the progress of the work, while disappointing for the first few months was made eventually to substantially exceed the schedule. The proposed rate was 100 cu. yd. per day from Oct. 17, 1919, to March 15, 1920, and 200 cu. yd. per day thereafter.

The Downs and Ups of Concreting.—Several interesting things are brought out on this chart. One is that at the beginning the curve of actual progress dropped distinctly below the 100 yd. per day set. The reason for this was the lack of sufficient gravel to keep up the pace, and this in turn was due to the necessities of the Baltimore & Ohio R. R. relocation. The Taylorsville borrow pit was in fact furnishing gravel ballast for the new tracks, and this continued from the beginning up to Dec. 16, the total furnished for this purpose during this period being 33,000 cu. yd., a fact noted on the chart. The equipment was not of sufficient capacity to keep both the railway and the outlet work going at full speed. The railway work was in fact delayed beyond the date originally estimated; hence the interference.

Fig 1—General View of Outlet Works.

It will be noted that the rate of actual progress did not at once pick up much, following the completion of the ballasting, and this was due to the winter weather. The season was rather severe, and this held the work back, a matter commented on later. From March 15 on, however, the rate accelerates at once as an average, to the standard 200 cu. yd. per day set, and so continues till the middle of June, when it again speeds up and about July 25 reached and crossed the line of the proposed progress. It dropped again as the work approached its end, unavoidably, as most concrete work slows up in the "puttering" details of finishing the job. The last concrete was poured on Sept. 25.

The rate of placing during July and August exceeded considerably, in fact, the expectation, and broke all previous records on conservancy work. This might perhaps be expected, the work being considerably more massive than any other conservancy job, and therefore permitting the development of more efficient "quantity production." Nevertheless, much credit must be given to those in charge, the chart showing that the work was finished about one month ahead of the expected date.

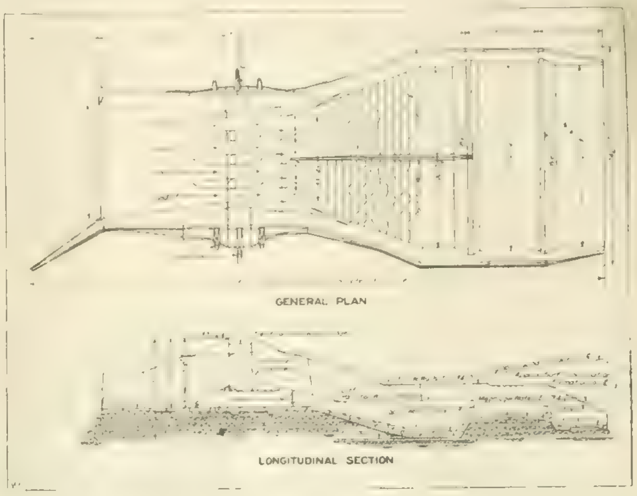

Fig. 2—Plan and Section of Outlet.

The record day's work at Taylorsville was 568 cu. yd. of concrete in place, made on Monday, July 29, the high record at any other dam being 374 cu. yd. This was in one 10-hour shift. The high week included the record day and ended July 24, with 2,408 yd. placed, or at the rate of 401 yd. per 10-hour shift. In 27 consecutive working days, 9,280 cu. yd. were placed, or at the rate of 343.7 yd. per day. The day's work was always in one 10-hour shift.

The men in charge of the work at Taylorsville have been O. N. Floyd, Division Engineer; H. L. Freund, Assistant Engineer; Ben. H. Petty, and C. O. Shively, successive Office Engineers, and H. M. Sherwood, Superintendent of Construction. Those in direct charge of the concreting were H. R. Daubenspeck, Assistant Engineer, inspector of mixing; W. J. Smith, Jr., Assistant Engineer, inspector of placing; and W. D. Rogers, General Foreman at the forms; and C. P. Heckman, Foreman at the screening and mixing plant.

The 10-Hour Day.—All men worked regularly 10 hours, but because of the state law this was on an 8-hour basis with time and one-half for overtime and double time for Sundays and holidays. Thus the regular daily pay was for 11 hours' work. Only emergency repair work was done on Sundays and holidays.

Working Force.—The accompanying organization chart is for the second week in August, 1920 (a period of rapid progress) but is typical for the summer work in general. The chart also shows rates of wages. In addition to the men shown on this chart men from the Master Mechanic's were called in for repairs of any magnitude. Also another labor foreman with a gang of from 8 to 10 men was often called in to unload cement when the regular concrete labor gang was busy at other work. The men on the mechanic's gang were paid 52 to 60c and the laborers were paid 46c to 47c.

CONCRETE ORGANIZATION, TAYLORSVILLE DAM, 1920.

General Superintendent
 Assistant Superintendent In charge of concrete, $280 month.
  Foreman In charge of gravel pit and mixer, $48 week.
   1 special laborer, $6 day
   1 mixerman, 56 ct. hour
   2 special laborers charging hopper, 47 ct. hour.
   2 special laborers trucking cement, 47 ct. hour
   1 special laborer stacking cement for trucks, 47 ct. hour.
   7 laborers, belt, dumping hopper, etc., 47 ct. hour.

Carpenter Foreman, 85 ct. hour.
  27 first-class carpenters, 80 ct. hour.
  18 second-class carpenters, 60 to 70 ct. hour.
  12 rough carpenters, 52 to 56 ct. hour.
Concrete Foreman—In charge of placing, 60 ct. hour.
  3 special laborers, 49 ct. hour.
Labor Foreman, 60 ct. hour.
  12 to 15 laborers, 47 ct. hour.
  2 derrick runners, 70 ct. hour.
  2 derrick tenders, 70 ct. hour. (These men could [illegible] when needed.)
  2 gasoline dinkey runners, 56 ct. hour.
  2 concrete finishers, 60 ct. hour.
  2 pumpmen on unwatering pumps, $30 week.
Train Crew—
  1 dinkey runner, 60 ct. hour.
  1 fireman, 53 ct. hour.
  1 brakeman, 50 ct. hour.
Dragline Crew—
  1 dragline runner, $250 month.
  1 fireman, 52 ct. hour.
  1 pitman, 52 ct. hour.

Note. Work 10 hours and pay for 11. Men paid by week or month are not paid extra for overtime or Sundays.

The concrete was usually placed by one derrick while the other derrick was handling forms and muck, but often on the heavier part of the work both derricks were placing concrete at the same time. In this case one of the rough carpenters was placed in charge of a second concrete placing gang.

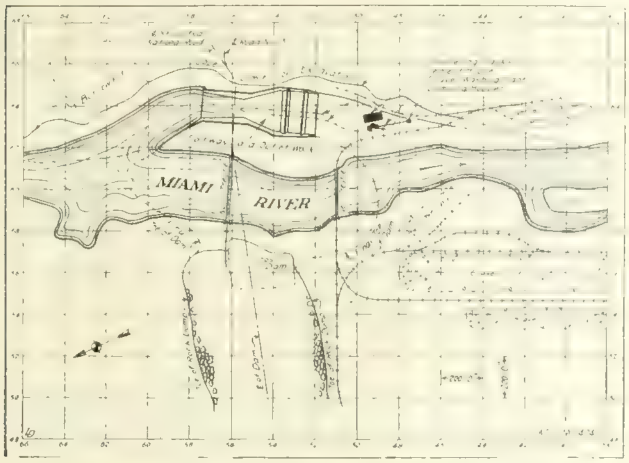

Fig. 3—Layout of Construction Work.

The Cost of Concreting.—The favorable rate of progress, indicated by the chart, is of course connected with the question of cost. The original estimate of this was $9.47 per cubic yard of concrete, as an average for the several classes of the material placed, the classes depending upon the amount of cement required, the difficulty of placing (as requiring pumping when below water level, for instance), and other factors. The $9.47 was divided into $2.87 for the cement (¼ bbl. at $2.30 per barrel), and $6.60 per cubic yard for the remaining items (shown in the table below). The actual cost has been $10 per cubic yard. The estimate was made in 1917. In consideration of the general conditions confronting construction work during the period when the work was being done, the showing is a very creditable one for the engineers and workers on the job.

The division of the cost per cubic yard, just referred to, is given in the following table. It is based on "pay yardage," computed to the "neat line" of the masonry, this quantity being 42,243 cu. yd.

The total amount poured was 44,340 cu. yd.

SUMMARY OF CONCRETING COSTS.

Item.	Cost per cu. yd.	Per cent of total.
Labor	$3.51	35.1
Supplies (cement, lumber, repair parts, etc.)	3.02	30.2
Power (coal, electricity, gasoline)	0.37	3.7
Plant (erection, depreciation, camp)	2.43	24.3
Industrial insurance (2.45 per cent of payroll); job overhead (20 per cent of payroll)	0.67	6.7
Total	$10.00	100.0

LABOR DETAIL OF COSTS PER CU. YD.

Laying tracks (in borrow pit)		$0.129
Excavating gravel		.333
Screening and washing gravel		.195
Mixing and placing		.540
Building forms		.941
Trestle and concrete tracks		.210
Repairs		.067
Placing reinforcement		.011
Unloading cement		.047
Cleaning up		.032
General and miscellaneous (including heating)		.437
Storing aggregate (extra labor only)		.067
Dismantling and general cleaning up		.500
		$3.51
Supplies (lumber, repair parts, conveyor belt, etc.)		$10.59
Cement (less credit on sacks)		2.20
Dayton shop (mostly on repair parts)		.23
Dayton Garage (hauling)		.01
		$ 3.02
Power—		
Coal (dragline, dinky and heating)		$ 0.132
Electrical at .02 per kwh		.227
Gasoline and oil		.016
		$ 0.37
Plant—		
Erection cost (approximate)	$0.60	
Depreciation at 2 per cent per month	.70	1.30
Camp—50 per cent of yearly depreciation		1.13
		$ 2.43
Industrial insurance (2.45 per cent of payroll)		$ 0.074
Job overhead (20 per cent of payroll)		.602
		$ 0.67
Approximate unit cost per cu. yd. (Based on 42,243 cu. yd. concrete.)		10.00

Supplies issued per cu. yd. of concrete:

Lumber	$0.11
Bolts and anchor washers	[illegible]
Conveyor belt	.02
Miscellaneous	.33
Boots and slickers	.06

UNIT COST OF CONCRETE, OCT. 20, 1920.

	Sq. ft. of form surface.				
	Forms.	Bulkheads.	Total, sq. ft.	Concrete, cu. yd.	Sq. ft. forms per cu. yd.
River wall	57,372	22,492	79,864	15,400.4	5.19
Land wall	40,401	9,341	49,742	7,869.6	6.24
Floor and weir	4,901	34,193	39,094	13,562.1	2.89
Weirs	17,225	.....	17,225	4,985.1	3.46
Center wall	8,042	570	8,612	556.9	15.46
3 piers	11,700	1,212	12,912	1,966.2	6.59
Total	139,641	67,808	207,449	44,340.3	4.69

Form labor, $41,820.55 + 861.16 (02B) = $42,681.71.
Form labor per sq. ft. of form surface, 20.6c.
Lumber, bolts, nails, etc. (approximate), 8.5c.

On March 1, pay of common labor was raised from $4.18 to $5.06 per diem, an increase of 21 per cent, and first-class carpenters from $8.25 to $8.80 per diem, an increase of 6.7 per cent. Average increase of entire payroll about 10 per cent. This general increase in wage scale added approximately $10,200 to cost of labor or increased unit cost of concrete, approximately 23c per cubic yard. Cement cost during first half of work, $2.85 per barrel, with an allowance of 60c for sacks, making a net price of $2.25 per barrel; a later contract was made for $3.19 per barrel, with $1 off for sacks or $2.19 per barrel net. Form lumber was purchased at about an average price of $40 per thousand. Unloading cement from cars into warehouse cost $4.83 per barrel.

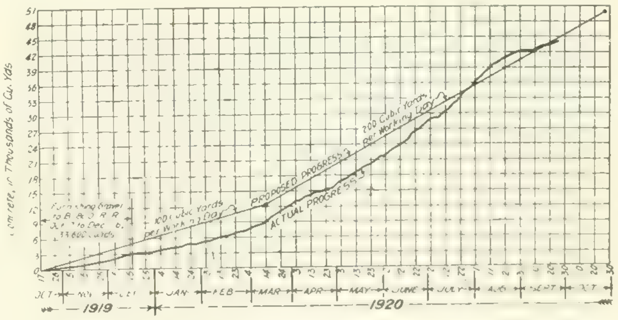

Fig. 4—Progress Chart.

Excavating, washing and screening gravel, labor	$0.44
Cost per cu. yd. gravel, pit run, plant	0.40
Supplies	0.06
Power	0.10
Overhead	0.10
Per cu. yd. gravel	$1.10

About 58,000 cu. yd. of pit run gravel was screened and washed to obtain sand and gravel for 44,340 cu. yd. of concrete, but there was always a surplus of sand of 20 per cent to 50 per cent of which was wasted with the used water, also considerable pea gravel was wasted.

Production Record and Mixture Details.—The work being most of it massive, with little steel reinforcement, the mix was in general, approximately, 1:3:6. It being convenient to measure the cement in the full bags as shipped, the measures to secure the proportions named were 4 bags of cement (1 cu. ft. to the bag), to 13 cu. ft. of sand, to 25.8

cu. ft. of mixed gravel, the latter figure being the result of mixing 16 cu. ft. each of the fine and the coarse grades, as given by preliminary tests. But practically, as stated, the 16:16 mix was varied to suit the run of gravel in the pits. A 1:3:6 mix would seem to require 12 cu. yd. of sand instead of 13, but as repeated tests, made regularly as the work proceeded, showed that 10 to 25 per cent of the "sand" which came through the sand screen exceeded ¼ in. in size and could be considered really as fine gravel, the extra cubic foot was added to secure a true sand ratio.

MONTHLY RECORD.

(Overbreak filler not included.)

	Cu. yd.
October, 1919	340
November	1,219
December	1,547
January, 1920	1,347
February	2,053
March	5,011
April	3,868
May	5,025
June	7,025
July	7,927
August	4,774
September	2,450

The above figures are from monthly estimates. Final estimate revised these amounts so that the total amount of pay concrete allowed was 42,243.2 cu. yd. Best day's run was on July 19, when in 9 hours and 30 minutes' running time, 437 batches or 567.7 cu. yd. of concrete were placed. On same day the washing and screening plant handled 53 12-yd. capacity cars of pit gravel. Mixer was a No. 28-S Smith power tilting 1 cu. yd. size, with a cone extension on discharge. Average size of batch 34 cu. ft. Ran one 10-hour shift only, and did not work on Sundays or holidays

In all 44,817 bbl. cement were used, an average of 1.01 bbl. per cubic yard of concrete. Standard batch, 13 cu. ft. sand; 16 cu. ft. small gravel; 16 cu. ft. large gravel and 4 bags of cement. For a 12-in. facing of walls, weirs, and floor, 6 bags of cement were used per batch. For a 12-in. lining of the conduits, 8 bags of cement were used per batch.

Aggregate was screened to three sizes on a set of rotary screens. Passing a ⅜-in. hole, sand; passing 1½-in. hole and retained on ⅜-in., fine gravel; passing a 3-in. and retained on 1½-in., large gravel. Over-size rocks, up to 6 in., were carried into the large gravel bin. By a measurement test of full size batches, a mixture of 16 cu. ft. of small gravel and 16 cu. ft. of large gravel gave approximately 28 cu. ft. of mixed gravel, with 35 per cent voids. This proportion of small and large gravel was varied at times to suit deliveries from pit. The average was about 18 cu. ft. small to 14 cu. ft. of large.

A total of 35,774 batches were mixed.

A new conveyor belt was put on March 14 (20-in. wide, Goodrich). This belt lasted till end of job, and was completely worn out, 4,400 cars or 52,800 cu. yd. of pit gravel were elevated on this belt. Original cost of belt was $2.22 per foot.

In all approximately 5,500 12-yd. capacity cars of gravel were washed and screened of which 4,200 cu. yd. of sand and 6,600 cu. yd. of gravel were stored for future work. Some of this was used for other purposes.

A. A. E. Railroad Conference March 14.—The third annual railroad conference of the American Association of Engineers will be held at the Congress Hotel in Chicago on March 14. Many delegates will be present from all over the country, representing the 50-odd sections of the association. Last year several hundred engineers attended the conference and this year the attendance is expected to be at least 500. The conference is an annual feature of the railroad engineering week in Chicago, being the occasion of the annual meeting of the American Railway Engineering Association and the annual railroad show at the Coliseum.

New Hudson River Railway Bridge.—The U. S. House of Representatives on Feb. 7 passed a bill authorizing the construction of a railroad bridge over the Hudson River at Castleton, N. Y. The bill had previously been passed by the Senate and now goes to the President. The new bridge will connect the New York Central Lines to New York and the B. & A. R. R. Lines to Boston with the West Shore R. R. and thus will relieve traffic congestion at the Albany gateway into New England. A large freight terminal will be built and special trackage laid.

U. S. Chamber of Commerce on the Street Railway Problem

In November, 1920, there was issued by the Chamber of Commerce of the United States to its members and associate members a report by its Special Committee on Public Utilities and a referendum ballot on the eight recommendations contained therein. The preliminary canvass of the ballots was published on Jan. 21, and is given below.

1. Existing traction facilities should be conserved.

In favor	1,689
Opposed	None

2. The attitude now taken toward street railway problems should be based upon the present and future needs of the community.

In favor	1,677
Opposed	None

3. The attitude which is taken toward street railway problems should contemplate private ownership and operation.

In favor	1,657
Opposed	24

4. Regulation should everywhere be instituted that will promptly follow changes in the situation of the companies rendering services of local transportation.

In favor	1,666½
Opposed	4½

5. Provision should be made against the consequences of unfair competition.

In favor	1,651
Opposed	16

6. All burdens unrelated to the service performed should be removed from the street railways.

In favor	1,460½
Opposed	167½

7. Official responsibility should be definitely fixed for the application of regulation.

In favor	1,682
Opposed	3

8. Each company should seek to have available for the public at all times the facts as to the results of operation and should have resident responsible executives wholly conversant with local requirements.

In favor	1,683
Opposed	1

Arguments in the Negative.—These were included as a supplement to the committee's signed report, but their origin was not stated.

Another supplement contained the conclusions and recommendations of the "Federal Electric Railways Commission," which are printed elsewhere in this issue. The committee placed great value upon these conclusions and the report covering them.

There follows an abstract of the Chamber of Commerce report, in which the "arguments in the negative" have been grouped, each with the recommendation to which it refers. The personnel of the committee is given at the end of the abstract.

Sources of Data.—Material for the committee's report was gathered in an intensive study of the problems in the course of which it received statements from economists, public officials, utility executives and employes and others. Further assistance was received through the detailed statements of local transportation conditions furnished by numerous commercial organizations.

1. Existing Traction Facilities Should Be Conserved.—The Federal Commission found that the electric railway industry is without financial credit and is not performing properly its public function. The commission concluded that the first essential is to restore credit to the street railways in order that they may obtain necessary new capital for the extension and improvement of service.

In this finding and conclusion the committee concurs, and it recommends that as the first step in bringing about this result existing traction facilities should be conserved. The attitude taken toward them by the public must be constructive and not destructive. The point of view must be that local transportation is an industry to be fostered and developed, with ample povision for correcting abuses and for preventing anyone from taking unfair advantage of the public attitude.

The importance of such a policy as the committee recommends has been emphasized by the United States Supreme Court, which said:

> Our social system rests largely upon the sanctity of private property, and that state or community which seeks to invade it

will soon discover the error in the disaster which foll [illegible] slight gain to the consumer which he would obtain from [illegible] in the rate charged by the public service corporations is as nothing compared with his share in the ruin which would be brought about by denying to private property its just reward, thus unsettling values and destroying confidence.—(213 N. S., 18.)

Importance of Adequacy.—Consideration of the nature of the service performed by local street railways, and [illegible] great place this service has in the local problems of readjustment to meet conditions following the war, emphasizes the outstanding truth of the Supreme Court's statement. Every phase of a community's interests and activties, whether social in the broadest sense or economic, is affected by the services of local transportation that are available to the public. Transportation facilities which are adequate and which keep pace with needs of communities that grow at the rapid rate distinguishing American cities in recent years contribute to the welfare of every member of the public. On the other hand, inadequate and inefficient facilities give rise to a constantly multiplying series of problems. Congestion of population results, often in the most undesirable districts, and brings in its train problems and consequences upon which we scarcely need dwell. Access to parks, educational institutions, churches, and other common resources of the city is made difficult and perhaps wholly cut off. Industries find themselves cramped in old quarters and cannot seek new sites, and the commercial life of the community may become concentrated and embarrassed by obstacles in transportation. In communities where, for one reason and another, traction services have been discontinued for a period, every inhabitant became keenly aware of the relation of local transportation to him and his affairs. That relation exists just as directly when, instead of total stoppage, there is anything less than completely adequate service.

Housing and Other Local Problems.—This is a time when traction service should be facilitating the solution of other problems, and not aggravating them. Among the problems affected by local transportation conditions is the housing situation. Provision of adequate and appropriate housing for urban populations is a pressing requirement for the hour. The question is not only how to obtain housing but how to utilize it, and utilization in every instance turns upon the facilities for local transportation. To a house, either new or old, access to an efficient street railway is quite as essential, for practical purposes, as sewer connections and a water supply. Clear recognition of this direct relation of traction services to utilization of housing was given by the government during the war, when it directly promoted local transportation for industries related to the conduct of the war.

Substitutes for Electric Railways Do Not Enter the Present Problem.—The transportation facilities which are here under discussion are supplied by electric street railways—i. e., by cars propelled by electric energy and operated upon rails. Some other means of providing local transportation may eventually be developed. That possibility has no place in the present discussion. The problem demanding solution is immediate, and the present solution must be found in the material now at hand.

Same Problems Abroad.—The problem which is before your committee is not to be understood as being peculiar to the United States. It has arisen in every country where there is a street railway. In the spring of 1920 the British government indicated that of 66 municipal street railway companies in the United Kingdom 20 had to receive subsidies from public funds and the 263 such companies in private ownership and operation had insufficient revenue to meet fixed charges and pay renewals. Parliament enacted legislation giving governmental authorities power to increase fares. Even so, in August the tramways of so important a city as Manchester were facing a deficit of $1,500,000.

Arguments Against Conservation of Existing Facilities.—The negative arguments presented are all based upon the assumption that private interests, when in conflict with public interests, are not to be considered. Three main arguments with some slight elaborations are presented in the report: (1) That the investors took a voluntary risk on entering the business. [To the editor of Engineering and Contracting it appears that these arguments treat far too lightly the differences between an independent competitive business and one which either originally or at some date after its inception, was placed under public control with a comparatively low limit of allowable earnings.]

(2) That in general there cannot be competition between street railways, and that competition, if it is to come at all, must be from other means of transportation.

(3) That any attitude now taken for the conservation of present facilities should not foreclose the public from having the benefits of future advances in local transportation. [It seems scarcely probable that any large number of people believe that progress in transportation should (or for any long period, could) be stopped by the interests of the present investors. True conservation means something very different.

It is interesting to note that recognition is given to the prospect of radical changes in transportation requirements through scientific city planning.—Editor Engineering and Contracting.]

Past Mismanagement.—In the United States one great cause for public indifference to the situation of local street railways lies in widespread belief that in the earlier history of many traction companies there was financial mismanagement.

Proper Method of Approach.—Even in cases where this has been the fact, however, it becomes relatively unimportant at this time, inasmuch as the problem should be approached from the point of view of the value of the property used for the public service rather than from the point of view of the outstanding securities. If it be conceded that the public interest is to obtain good service at lowest cost and that street railways are essential and necessary, then the sensible way to deal with the problem is to permit existing organizations and present properties to earn a sufficient sum over their operating expense to induce investment of capital for extensions and improvements to existing facilities. It is not a question of past financing but of present earnings and there should be provided a margin sufficient to attract new capital. This will result in the end in the most efficient and cheapest service to patrons of utilities and to the public in the communities served.

Recommendation No. II.—Believing that this position is in the highest public interest, the Committee recommends that the attitude which is now taken toward street railway problems should be based upon the present and future needs of the community, and not upon earlier conditions. Equitable readjustment and not past performance is the immediate problem.

Arguments in the negative, including the comment on holding companies, are presented as follows:

A public attitude such as is recommended by the Committee, based upon present and future needs, would not solve the problems that cause difficulty. It is past events, in the period before regulation, that now cause such controversies as disputes over the proper method to be used in valuation. Those disputes are justified by reason of the bona fide investments which have become involved. The shortest way to a solution of traction problems is to settle these controversies. When they are out of the way, there can easily be agreement that the valuation plus future contributions by owners is the just amount upon which owners of street railways should have fair return commensurate with the efficiency of their efforts and the prevailing rate of risk.

Holding Companies.—There are also problems of organization continuing out of past conditions. Holding companies persist, although according to census reports there would appear to have been some decrease in number in the street railway field. Holding companies are often operating companies, controlling a number of subsidies with a complexity of corporate relationships, including numerous bond issues, rental charges, and over-lapping agreements. Corporate relationships should be simplified and made more direct. Such a reform would frequently tend to fix responsibilty and decrease expense.

Public Ownership.—Although the Committee, in seeking to develop all possible points of view, received statements from advocates of public ownership, it has been unable to discover any reasons which would justify belief that better service or lower rates would accrue from public ownership. On the contrary, the Committee had before it persuasive reasons showing that public detriment would follow. In European countries where there is to an extent public ownership exactly the same cases has appeared as in the Un[illegible] country none of the attempts at municipal ownership and operation of street railways, as in Seattle and to an extent in San Francisco, has yet demonstrated advantages to the public.

Costs Borne by Public.—No [illegible] by whom or in what manner the service is provided, whether by private or public operation, the community must ultimately pay all necessary costs. They must be paid either by the farepayer or by the taxpayer; what the farepayer does not pay the taxpayer must pay.

To continue rates of fare under which the street railway industry cannot be self-supporting is to force the abolition of private and the substitution of public operation. The community cannot gain thereby unless it can materially reduce the costs of street railway operation. The Committee has considered that possibility.

It would be superfluous to argue the proposition that no industry operated by private capital can long continue when the expenses exceed the revenues. If the street railway industry is to serve the people with the efficiency which the latter demand, it must be put and kept on the same basis as that upon which all efficient industries rest, namely, that of self-support and reasonable return. Private capital will not embark and cannot remain in an industry which is artificially precluded from earning its costs plus a reasonable return.

There is abundant support for the conclusion that public operation of street railways instead of diminishing would increase the cost of street railway service and at the same time lower its efficiency.

More Efficient Personnel in Private than in Public Management.—No business can be carried on efficiently and economically except by men having special training and experience therein, qualified by expert knowledge and ability, stimulated by self-interest, and secure in their tenure during efficiency.

The public service does not attract and does not often long retain men with the qualifications without which the maximum of efficiency and economy is impossible. The pay in the public service, especially in the higher grades, is relatively small. The tenure is uncertain and brief. The opportunity for advancement is slight. Unusual zeal and exceptional ability bring little or no reward, and the powerful incentive of self-interest is paralyzed.

In almost uniform practice important public business undertakings are entrusted to men without the special knowledge, the skill and the experience indispensable to good management and low cost. Nor can inexperienced officials, however intelligent and zealous, acquire full efficiency during the short time they are in office.

Moreover, public officials even if properly qualified personally for their duties are so hampered by restrictions of law, by insufficient discretionary powers and by co-ordinate or superior authority as greatly to limit their effectiveness.

With the results of this condition of affairs the public is already familar in other directions. A continuous and well-defined policy becomes impossible. In its place invariably appears a series of experiments directed by inexperienced officials. Co-ordination and efficiency cannot exist under such circumstances. For the public there are at the same time burdens from added costs and a lack of adequate service.

Relative Efficiency.—The relative inefficiency of public as compared with private management is well illustrated by a comparative study published in 1918 and presenting the facts regarding 17 municipal and 18 private electric lighting plants in Massachusetts. In every essential element of cost the showing was markedly against the municipal plants. To manufacture current cost the municipal plants 33 per cent per kilowatt hour more than the cost to private plants; to distribute current 20.7 per cent per kilowatt hour more. Their labor costs at station per kilowatt hour were 53 per cent in excess of those of the private plants; their excess of fuel costs per kilowatt hour was 13.2 per cent. The labor efficiency of the municipal plants, as gaged by the product of current per employe, was 26 per cent below that of the private plants. The municipal plant's loss of current by leakage or otherwise was 31 per cent more than that of the private plants. This was probably due to bad engineering, due in turn to inefficient general management and supervision. The municipalties paid 7.4 per cent per ton more for their coal than was paid by the private plants. For an equal result the municipalities consumed 15 per cent more coal than the private plants consumed. Excluding taxes, the operating expenses of the municipalities exceeded those of the private plants by 20 per cent.

It is not practicable to present here in detail a vast body of available evidence which demonstrates conclusively that under government operation operating costs rapidly and wastefully increase and are almost invariably much in excess of those of private operation, and that such excess cost is usually coincident with low, and frequently with absolutely decreased efficiency. A few examples may, however, be cited. A case in point is the operation of the American railroads by the United States government.

Tremendous Inefficiency in Europe.—Another instance is supplied by Italy. In 10 years 50,188 employes were added to the payroll of the Italian government railroads without the addition of any new mileage, and without improving the service. Before the government took the roads, they paid small dividends, besides annually paying $10,000,000 to $12,000,000 in taxes. Since governmentalization the annual deficit from 1905 to 1914 has been from $35,000,000 to $42,000,000, to say nothing of the loss in taxes. After the French government took over the Western Railroad system, in five years the operating costs increased from 67.8 per cent to 89.4 per cent of the gross revenue—an increase more than 2½ times that of the private French lines during the same period. This staggering increase did not go to produce better service, but went for new and needless employes. Where the private companies employed 174 persons, the state railway employed 235 persons; where the private lines paid $57 in wages, the state lines paid $97. The new appointments were largely political. Discipline and service were completely demoralized.

Published Accounts May Be Misleading.—Some communities have apparently believed that public operation has provided them with lighting and water service at less cost than those services could be obtained from private companies. Public accounting seldom exhibits the true costs of a particular service. Charges for renewals and replacements are often entirely ignored. Sinking fund outlays, interest charges and rents arising from the particular service are often charged against other funds. Tax losses are disregarded. By omitting or improperly disposing of these items of expense the actual cost of a utility service is concealed, and the public is led to believe that it is getting that service for much less than it is actually paying for it.

Recommendation No. III.—A canvass of every consideration that has been brought forward in support of public ownership has resulted in the Committee's finding in it no solution for present problems or means for meeting future requirements. The Committee accordingly recommends that the attitude which is taken toward street railway problems should contemplate private ownership and operation of local transportation facilities.

Arguments for Public Ownership.—The following is given under "Arguments in the Negative":

Since the Committee made its report a committee of the National Association of Railway and Utilities Commissioners has declared that the question of public ownership and operation "should no longer be considered by intelligent investigators as open," because it has been foreclosed through failure of public ownership and operation wherever it has been properly tested. Such statements should be supported with data analyzed from an impartial point of view.

The Committee supports its recommendation by data which is not conclusive. In order to arrive at a decision respecting public ownership and operation one should first fomulate standards by which success or failure is to be measured. The experience of any foreign country should be estimated according to its own peculiar conditions. By way of illustration, it might be pointed out that, even if it were conceded that in the United States, government operation would be more costly than private operation, it is essential to ascertain if this excess cost is offset by the lower rate at which a municipality can obtain capital.

From the theoretical point of view a number of arguments are advanced. It is argued that street railway transportation is of such general and essential importance to the community that its provision is a public function, much like the supply of water. It is said that some incidents, such as the desirability of a rate of fare that does not vary approximately with distance, places a burden upon a private company that should be assumed by the whole public, since it is in the general interest of the community that all parts of it should obtain its transportation at equal rates. If there are deficits for private companies in meeting these conditions, and in furnishing a quantity and quality of service the public interest requires, it is said to be inconsistent to use the taxing power to make good the deficits accruing to private enterprises. Public ownership and operation is sometimes advocated as the only means for obtaining a unified traction service in some cities, and of remedying the complex corporation relationships which have been created. Finally, it is contended that private enterprise has had the task of supplying management and capital in an industry constantly requiring large amounts of new capital, and having reached a point where it cannot furnish the new credit that is needed it has failed and should be replaced by a public agency.

Modern developments in the United States at least open the way for public ownership and operation. A number of cities have found some relief from their difficulties through cost-of-service franchises and indeterminate permits; both expressly contemplate public ownership as a possibility. Inauguration of regulation likewise points toward the possibility of substitution of public operation for private ownership with public regulation. In fact, if regulation breaks down in that it does not produce the benefits that are required by the public interest, there would seem to be no alternative to public ownership and operation. Some cities take the position that no satisfactory system of regulation has yet been devised

IV. Regulation Should Conform to Changing Conditions.—This is very nearly self-evident, and is treated only briefly in the report.

The negative arguments are chiefly in elaboration of the statements, "Flexibility is only an incident to regulation. It is more important that regulation should be thoroughgoing."

V. Provision Should Be Made Against the Consequences of Unfair Competition.—This does not mean that local transportation as it now exists should be perpetuated regardless of advances that may be achieved in the art of transportation or in the science of regulation. It does mean, however, that a company which is rendering service and should be developed in efficiency should not be subjected to competition from any other source which is not under corresponding regulation and obligations.

VI. Unrelated Burdens Should Be Removed.—The whole purpose of regulation likewise implies that the companies subject to regulation should be responsible only for performing the service they have undertaken. Their efficiency and the reasonableness of their rates of charge are the matters which should have undivided attention. Reasonableness in rates should be decided only with reference to the service that is rendered. In other words, the rates charged for street railway transportation should not be made an indirect method of taxation for the community. A street railway company should be taxed only on the basis of other comparable taxpayers.

The negative side of this question is presented thus:

In recommending that street railway companies should be relieved of burdens unrelated to the service they render, the Committee obviously has in mind liabilities for repairs of pavements, removal of snow from streets, payment of salaries for traffic policemen, etc. The variety of these liabilities imposed in different cities is large.

Consideration of the propriety of these burdens should not overlook the fact that surface traction companies occupy the streets, which in one form or another are public property. In this respect they differ from steam railroads generally, since the latter for the most part occupy lands which they have acquired. The streets require public expense for their maintenance and for the supervision of traffic. It is not inequitable that an enterprise which occupies a considerable part of this property, by its method of operation causes special deterioration of the street surface, and contributes to congestion and other undesirable conditions should assume at least part of the cost of maintenance and supervision.

Recommendations Nos. VII and VIII.—These are treated only briefly in the body of the report, but the Arguments in the Negative are of greater length and interest.

Official Responsibility—The Negative Argument.—Administrative officials applying principles of regulation which have been decided upon by legislative authorities have duties which are more judicial than executive. In the performance of their duties they are under obligation to follow laws which a legislature directly responsible to the electorate has enacted. The success of the application of the principles depends much more on the ability with which the legislative authorities performed their duties than upon the action of the administrative agency. If the administrative agency does not follow the legislation which has been enacted, it becomes the duty of the executive authority to exercise its power of removal, or of the legislative body to use its powers of investigation and impeachment. The nature of regulation and the distinction clearly drawn among duties in our form of government make it improper to charge an administrative body with direct responsibility for getting successful results from regulation.

Facilities for Local Information Will Not Take the Place of Local Ownership.—Good service to the public is the source of good will from the public and good will, or the lack of it, determines whether public regulation will be formulated and applied from a constructive point of view or will reflect a hostile attitude. Good service from a utility that is peculiarly local requires that the ultimate private responsibility, which resides not in management but in ownership, should be local.

That this has not been the case is stated by the Federal Electric Railways Commission, which said:

> Through the system of financing and management the utilities have been largely controlled by persons living distant from the community affected by a particular electric railway, whose prime consideration has been to secure a return upon the property. This "absentee" management and control has not been successful in bringing about the proper spirit of co-operation between the local managers, employes and the public. Since the electric railway companies come into immediate daily contact with large numbers of people, it is of the utmost importance that the industry should gain and hold the respect, confidence and good will of its patrons. If the local public should invest its money in the stock and bonds of its local utilities there would be an improvement in the relations now existing between the corporation and the public.

[In this discussion the subject has been shifted from one of publicity to one of ownership.—Editor Engineering and Contracting.]

Personnel of Committee.—Pierson, Lewis, E., chairman: Banker, of New York City; chairman of the board, Irving National Bank of New York; formerly president, American Bankers' Association; vice-president, Merchants' Association of New York; a director in the Chamber of Commerce of the United States.

Bradlee, Henry G.: Engineer, of Boston; president, Stone & Webster, and director in numerous public utility corporations; member, Committee on National Relations, American Electric Railway Association; member, Boston Chamber of Commerce.

Brady, Arthur W.: President, Union Traction Co., Anderson, Ind.; formerly president, American Electric Railway Association; formerly member, War Board of the American Electric Railway Association.

DeBerard, F. B.: Director of Research, Merchants' Association of New York.

Hall, E. K.: Lawyer, of New York City; vice-president, American Telegraph and Telephone Co.; formerly vice-president of the Boston Chamber of Commerce; formerly member, Committee on Education and Special Training, War Department.

Harris, Albert W.: Banker, of Chicago; president, Harris Trust and Savings Bank.

Harrison, Charles L.: President, Board of Sinking Fund Trustees, Cincinnati; a director in the Cincinnati Chamber of Commerce; formerly chief, Cincinnati Ordnance District.

Lieb, John W.: Engineer, of New York City; vice-president, New York Edison Co.; president, Edison Testing Laboratories; recently president, National Electric Light Association, and formerly president, American Institute of Electrical Engineers.

McCune, H. L.: Lawyer, of Kansas City; senior member of McCune, Caldwell & Downing; member, Kansas City Chamber of Commerce; formerly circuit judge in local courts.

Myers, Paul N.: Manufacturer, of St. Paul; vice-president, Waldorf Paper Products Co.; president, St. Paul Association of Public and Business Affairs; formerly chairman, Regional Committee, Resources and Conversion Section, War Industries Board.

Van Allen, John W.: Lawyer, of Buffalo; member of Wilcox & Van Allen; vice-chairman, Transportation Committee, All-For-Buffalo Committee.

Engineer for Locomotive Inspection for I. C. C.—The United States Civil Service Commission announces an open competitive examination for senior mechanical engineer, Grade 1, to fill vacancy in the Bureau of Locomotive Inspection, Interstate Commerce Commission, Washington, D. C., at $3,000 to $3,600 a year, and vacancies in positions requiring similiar qualifications at salaries ranging from $3,000 to $5,000. Receipt of applications closes March 29.

Pacific Coast Cross Ties

In the Cross Tie Bulletin of January, Mr. E. O. Faulkner, manager of the Tie and Timber Department of the Santa Fe Railway System, has an article with the above title in which some experience is given relating to varieties of wood, methods of handling, and prospects for future supply. The following is quoted from the article:

Redwood and cedar timbers contain an oil that seems to help materially in retarding decay, so that as a rule in the case of cross ties made from them not more than 20 per cent are removed for decay and the rest for mechanical wear; of these latter a fair proportion are still suitable for fence posts and many such can be seen in use on the railway right of way. The chief trouble is their softness, the redwood a little more so than the cedar, which in reality is a cypress; to overcome this large flat tie plates are used, the Santa Fe standard having two small ribs ¼ in. deep on the under side of the plate parallel to the rail, which embed themselves in the wood and materially help in reducing re-spiking and rail spreading. All ties on the Santa Fe are plated.

The value of the redwood for tie purposes seems to merit special effort to overcome its main fault, mechanical wear, and a number were dowelled; that is, hardwood dowels or plugs 2 in. in diameter at the top, tapering to 1½ in. at the bottom, with a heavy thread cut on the outside, were screwed into corresponding holes bored in the tie in sets of two or four under each rail base, then tie plates placed over them to equalize the load, in this way making hardwood ties of them in the most vulnerable places, in fact, better than that, because the dowels were made and inserted parallel to their grain, so that rail cutting or abrasion would be reduced to a minimum. A number of dowelled redwood ties have been in the track since 1910 on a 10° curve on the Arizona division, under the heaviest traffic and axle load conditions, and at a recent inspection showed up all right. As an ordinary redwood tie will last there about 10 or 11 years, the further service from these now applies wholly to the dowelling. After the cost of this is met, the profit begins, which will determine further work of this character.

Practically all our redwood ties are split, the specifications requiring that "butt cuts" must be made into ties as well as from the rest of the tree. These "butt cuts" are locally known as "sinkers," the wood being so dense and heavy that it sinks in water, and so far as service is concerned, will last twice as long as ties made from near the top of the tree, in fact the difference in strength and length of service between a tie is so marked that we segregate the two kinds for the service which best suits each, and by a simple contrivance separate the heavy ties from the light ones at time of loading and mark them, the heavy going into main line and the light into side tracks.

Port Orford cedar is only found in the Coos Bay District in Oregon, mixed among the fir and and not growing in pure stands. The wood is somewhat harder than redwood, consequently holds the spike better and is equally as durable and desirable for cross ties, but its scarcity and commercial value for other purposes creates such a demand that comparatively speaking very few of these ties are on the market.

Fir and kindred trees will undoubtedly be the prevailing tie timber for this coast, and assuming the present perforating experiments are successfully worked out so that the timber can be more thoroughly and successfuly treated —and I see no reason why they should not be—it will be in general demand for ties, not only locally, but east of the Rockies and for export. The Forest Service reports that today one-half the standing timber of the United States is in the states of Washington, Oregon and California. Such being the case, it becomes all the more necessary to conserve the tie supply, and by treatment make it last its maximum life. Many roads have experimented in steel and concrete ties, hoping to find a satisfactory substitute for the wooden ones, but so far without much success, the old fashioned tie being still in popular demand and likely to continue so, and its value as such is so great that it is criminal to use it untreated. Compared with untreated, the benefit and economy of using treated ties is now so thoroughly established, and the opportunity of getting them properly treated is within easy reach of all sections, that any railroad using untreated ones made from timber susceptible of a prolonged life by treating, should be posted as a waster of natural resources, and for that matter so should tie makers as well as sawmill companies, if they allow any avoidable waste in converting the raw material to a manufactured and merchantable shape. We are using several times more timber in quantity each year than the increase in growth, and unless we properly conserve the supply the time is not far distant when wooden ties will be beyond reach so far as cost is concerned.

For some distance east of the Rocky Mountains, west to the Coast, there are no hardwoods suitable for tie making, which is quite a drawback, as mountain railroad maintenance, especially on curves, would be much helped if a supply of these was available. There is a so-called California white oak—known as valley oak—which bears a resemblance to the eastern white oak, but is not found in sufficient quantities to make an impression. The trunk of the live oak is too short, and as a rule irregularly shaped, to be considered in this connection. Two tie cuts could seldom be had from one tree, and their value is likely to remain largely in ornaments to the landscape.

A good deal has been said and written about eucalyptus ties from locally grown timber. This is admittedly a hardwood, but some of its other characteristics are such as to practically unfit it for use as ties for the time being. As is generally known the gum varieties are exceptionally quick growers. They usually have straight barrelled trunks of small taper, so that when conditions are most favorable they grow to tie size in about 12 years, but if they are then felled and cut into 8-ft. lengths they will split and check to such an extent as to render them wholly useless for the purposes. Due to its quick, vigorous growth the wood is generally full of sap, which the warm atmosphere expands to such an extent that it creates an inside pressure which must obtain an outlet, and thus tears or splits the fibre of the wood apart in escaping. This checking is the bane of the young eucalyptus, and several years ago the Forest Service made numerous and lengthy tests to try and overcome it, which I think they did to a certain extent, but the methods were such that it would not be applicable to ties. On several occasions when parties have written, wanting to make ties, we have agreed to accept them, but before they could be made and hauled to the right of way they were practically useless for such purposes on account of checking, and would have to be converted into cord wood. The loblolly pine of Texas is the quickest growing of any of the conifers down there, but even under favorable growth conditions it takes pracitically 40 years to attain the same diameter as some red gums do here in, say, 20, but such loblolly when made into ties will not check a tenth part of what the others will, even though the sap ring is as great if not greater, this presumably being due to the fact that the construction of the pine timber offers better opportunities for sap escaping than the other.

Some one may ask why Australian-grown eucalyptus ties give such excellent results. These again are made from trees in natural forests, possibly 200 or 300 years old, many older than that, some being over-matured so that they have "pipe heart." Like our redwoods, the ties are mostly split, the timber splitting easier and more regularly even than redwoods, in fact, the wood is very similar in many respects, but harder and more durable. For height, size and appearance a grove of such trees reminds one very much of a grove of redwoods in northern California, and it would be unfair to expect the same results from our recently planted trees as given by those old timers. I do not say wait 100 years for ours. Less than half that time should do, but the quality of the timber will then be such as to put it out of reach for ties.

The possibility has been suggested of being able to import hardwood ties from foreign countries, but in my opinion the leopard will have to change its spots before any appreciable number is obtained from such sources. I think I am correct in saying the Santa Fe has done more investigating and experimenting in that line than all the other roads in America put together, and we have come to the conclusion that the ties to be had at home are not so bad after all, although I will admit we would like to have some of these fine foreign hardwoods for curves if we could get them, but the domestic tie maker has no reason to be afraid of foreign tie imports.

Portable Electric Logging Yarder and Loader

The application of electric apparatus to the various processes in sawmills is widespread, but it remained for the Snoqualmie Falls Lumber Co. of Snoqualmie Falls, Wash [illegible] it on actual logging apparatus in the forest

This company has at present for this work in the woods

Portable Transformer Substation With Two 250 KV-A., 3-Phase, 13200/600 Volt Transformers.

a yarder and loader both mounted on the same sled. The former is a Williamette Iron Works Humboldt 3-drum yarder, having for motive power a General Electric 200 H.P. phase wound induction motor used on a 3-phase, 60-cycle, 550-volt power circuit. The loader, also built by the Williamette Iron Works, is equipped with two G. E. 75-H.P. phase wound induction motors. The two machines each occupy half of a 60-ft. sled, which renders them portable.

Electric Yarder and Duplex Loader Mounted on Sled.

The power supply for the two machines is stepped up to 13,200 volts at the mill power plant, by three 250 Kv-a transformers transmitted through the woods, and stepped down to operating voltage by two 250 Kv-a single phase 600/13,200-volt transformers, on the scene of operations. The transformers are rendered mobile by being mounted on a small sled which is equipped with a disconnecting switch. This sled is set about 500 ft. distant from the one carrying the yarder and loader, energy being transmitted between them by a flexible armored cable laid on the ground.

Some difficulty was experienced at first in obtaining desired slow speeds on the yarder, but when this was overcome by the insertion of resistance in the phases of the rotor, the operation was highly satisfactory. In 1918 the machine yarded 3,144,898 ft. of timber in 44 days, or an average of 71,470 ft. per day. In 1919, due to increase in the transformer capacity the average per day was raised to 77,000 ft. per day.

The same efficiency which characterizes the operation of the electric yarder is demonstrated by the loader. The application of solenoid load brakes to the motor makes it possible to hold a log suspended in mid-air, or in any position desired. This is made possible by the fact that when power is shut off from the motor the solenoid brake sets automatically, so as to prevent any motion.

Foreign Experience with the Trackless Trolley

The Amercan Electric Railway Association has recently collected some information on the operation of trackless trolleys in England, Germany, Austria and China, and this has been summarized by Mr. James W. Welsh, Special Engineer of the association, in the February number of Aera. According to Mr. Welsh very complete responses were received from the Leeds City Tramways and the Rotherham Corporation Tramways of England, the Shanghai Electric Tramways of China, and the Vienna Municipal Tramways of Austria, in answer to a questionnaire covering in great detail operating methods, costs of construction, etc.

The four companies are operating trackless trolley routes ranging from 1 mile to 5 miles in length through urban and suburban districts which are in general a co-ordinate although minor branch of the general transportation system.

The advantages claimed by these companies for the trackless trolley are its low initial capital investment compared with tramways and, on the other hand, a cheaper operating and maintenance cost compared with the motor bus. From the standpoint of the car rider it is claimed, it provides a service of equal reliability and comfort, and in many cases the operation is faster and smoother, especially where the streets are well paved and maintained. It offers the disadvantage, however, of a smaller carrying capacity than the tramways and less flexibility than the motor bus. The four companies referred to own from four to eight vehicles each, ranging in weight from 3½ to 5 tons and in seating capacity from 16 to 30, with a maximum capacity ranging from 24 to 60, the latter figure being reported by the Shanghai Electric Tramways. As these companies have been in operation from as easly as 1908 in the case of Vienna, 1911 and 1912 in the case of the English companies, and 1915 in Shanghai, their experience on maintenance and depreciation is of some interest. The English companies state that the average life of bodies for trucks is from 8 to 10 years, while the Austrian company uses a depreciation figure of 5 per cent.

The method of collecting the current is by means of trolley poles in the case of the English and Shanghai companies. The Rotherham company, however, employs a cast iron skate instead of the trolley wheel on each of the double trolley poles, while the Shanghai company uses a single trolley pole with a branch head. The Vienna company uses a small over-running carriage connected by a cable to the car.

In none of these equipments is there any provision for heating the car.

While these cars in general are operated by one man, the total number of employes assigned to trackless trolley operation including maintenance and repairs is approximately three men per car.

The average power consumption is one kilowatt hour per vehicle mile. The average schedule speed including both rush hour and non-rush hour periods for city and suburban districts is 8.4 miles per hour in Leeds; 9.4 miles per hour in Rotherham; 6 miles per hour in Shanghai and 12 kilometers per hour in Vienna.

Minimizing the Risk in Contracting*

By WM. P. KING.

Of King & King, Attorneys, [illegible]

Three Forms of Contract.—Construction work is commonly carried on under one of three forms of contract: the cost-plus, unit price or lump sum contract.

If the cost-plus contract could generally be adopted the risk in contracting would largely be eliminated. Many of the abuses discussed in this address find no place under it. Its uses are limited. It was the only possible form for much of the work during the war, but in spite of the fact that it achieved splendid results it fell into popular disfavor. It changes the fundamental relation of owner and contractor. Under other forms of contract the financial interests of contractor and owner, as to excellence of workmanship and completeness of compliance with the specifications, are opposed; under a proper cost-plus system they agree.

Whether this extremely advantageous method of contracting comes into general use depends largely upon the confidence which individual contractors are able to inspire in the minds of owners, personal or corporate, and upon the recognition by owners that their greatest interest is in having the best building and paying a reasonable price for it.

In promoting the cost-plus contract the effort should be in favor of some form of cost-plus-fixed-fee, rather than cost-plus-percentage. It will be much easier to establish the former than the latter.

The unit-price system tends to eliminate the contractor's risk by paying him upon the basis of the work actually done rather than by making him responsible for errors in estimating the work to be done. It is otherwise open to the same abuses as the lump-sum contract and the dangers hereafter pointed out and the remedies suggested are equally pertinent to it.

It is much more applicable to engineering than building contracts. It ought to be used in preference to a lump-sum contract, if cost-plus is not available, in all cases where the work to be done is susceptible of division into prescribed units and where there is any uncertainty about the ultimate plans or the conditions to be encountered. But there should always be a proper variation in the unit prices if the number of units varies materially.

The lump-sum contract in its ordinary form throws upon the contractor not only the legitimate risk, but also the risk of the correctness of his calculation of quantities and of the sound judgment and personal disposition of the architect or engineer. Some of these risks can be eliminated, as will be hereafter discussed.

Every lump-sum contract possesses in the minds of most owners one substantial merit often outweighing all others; namely, that the owner knows in advance what the work is to cost. This will keep the method in general use; so the contractor's interests, therefore, must be carefully safeguarded.

Under present systems of lump-sum contracts the contractor has three branches of work, equally necessary for his financial success. The first is estimating the quantities of material; the second is estimating the cost of placing these materials in the work; the third is the ability to do the work economically and within the estimates.

The estimating of costs and the execution of the work within those costs are uncertain factors. The skill of the contractor finds its opportunity here. His judgment as to markets, his business connections, his judgment as to the future cost and efficiency of labor decide his estimates. His ability to select suitable superintendents and foremen, his elimination of unnecessary overhead and the capacity of his organization for teamwork determine whether he can execute his work within his estimates. These are the legitimate fields for competition, where the most competent man will prove most successful. Variations cannot be eliminated as long as men are of varying degrees of ability.

Advantages of the Quantity Survey.—The estimate of quantities is a different matter; this is purely mathematical. Generally speaking, there can be but one bill of quantities if the plans and specifications are clear and susceptible of but one meaning. The figuring of quantities is really a part of the specifications. It often requires the interpretation of them. A bill of quantities is a definition of the extent of the work required by the specifications. It is the part of the owner to declare to the contractor not only the ultimate structure to be achieved but also the necessary constituents to that result. The contract fixes the conditions of performance of the work, the drawings show the structure to be built, the specifications describe the material to be used and the manner of use, and the bill of quantities, to complete the description of the job, should state the quantities of materials to be used according to the owner's interpretation of the drawings.

In Great Britain it has long been recognized that the bill of quantities is the owner's responsibility. In this country the contractor has assumed this risk. The British practice is sounder in principle.

Beside eliminating the contractor's risk as to quantities the quantity survey presents two other distinct advantages:

The efficient contractor has usually built up an adequate estimating department. The more efficient this is the more certain it is to include the entire quantity of every material. The efficient contractor has as a competitor a host of inefficient contractors who have no capable estimating organization. They are far more likely to estimate quantities too low than too high. The inefficient contractor, by reason of estimating quantities too low, bids low, gets the job and loses money on it. His error thus deprives the efficient contractor of an opportunity to do the work to the satisfaction of the owner and at a profit to himself. The adoption of the quantity survey would relieve the efficient and skilful bidder of the fallacious competition of the man who figures quantities too low. The quantities should be figured and guaranteed by the owner and provision made in the contract for an increase or reduction of the contract price for errors in the guaranteed quantities.

This practice would save the contractor's overhead. The cost of the estimate on the work not secured either eats up the contractor's profits or is paid by the owner whose work he gets. In any event, someone pays for on the average probably ten times as much estimating of quantities as is necessary. If a quantity survey is made and guaranteed by the owner the cost is of only one estimate and it falls directly where it ought to fall—upon the owner.

More Precise Forms of Specifications Needed.—This country is deficient in specifications of material and of methods of work. It ought to be possible in the case of almost every material to say that it shall conform to a given grade of fixed and known standards prescribed by a central organization. This would take the place of the old and inexact form: "Unless otherwise prescribed, all material shall be of the best quality."

The contracts of the United States engineering department fix the quality of cement by reference to tests prescribed by certain official publications. Lumber is often specified to conform to the classifications of the lumber manufacturers' association. The U. S. Bureau of Standards has published some standards of quality. There are standard codes of practice for electric and gas installation. Very fine constructive work has been done by the American Society for Testing Materials. These definitions have generally been of materials and have not included methods of doing work. Like standards and exact definitions should be made of every material used in construction and of every process of installation. The result would be that every contractor would know at once exactly what he was required to furnish and would not be dependent upon interpretation by any engineer or his subordinate.

How loose these specifications have been in the past is illustrated by a case in my own practice in a contract made some years ago by the United States. The specification for framing lumber was in the following terms:

> All framing or other lumber to be thoroughly seasoned straight-grained and square-edged, free from shakes, wanes, large or loose knots, and other imperfections impairing its durability.

This is supplemented by the following:

> All framing and other lumber, except where specified below, to be bright southern yellow pine; sap on one edge and extending [illegible], this not more than one-third on each face will be admissible.

It is not surprising that the general contractors endeavoring to obtain bids from lumber manufacturers under this specification were advised generally by them that they would not bid on such vague specifications and were obliged to go back to the United States officer and insist upon his amending the specifications so as to permit the use of lumber in accordance with the carefully detailed classification of the Southern Lumber Manufacturers' Association.

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*[illegible] national con-[illegible]

Loose, uncertain and discretionary specifications should be excluded. In a recent contract for paving the streets of a town in Virginia the materials were defined with a moderate degree of accuracy, but the specifications contained the following loose requirement:

> The materials used must comply with the requirements of [illegible] specifications and be suitable for use upon the street or streets to be paved. They shall be mixed in definite proportions by weight, depending upon their character and the traffic upon the street, and such materials and proportions must be satisfactory to the engineer.

The engineer was quite unfamiliar with street paving and varied his requirements of quantities of the different materials from day to day, finally stationing at the mixer a man who dictated what should be done according to his own daily judgment. Any practical man knows what the result of this must have been upon orderly work at the mixer, upon obtaining the proper materials and having them delivered on time. The specification quoted was a cover for a want of definite knowledge as to what was required.

In the same specifications for street paving the town assumed the responsibility for putting in sewer and water pipes. It relieved itself from any definite obligations by the following provision:

> The town will use all reasonable care and diligence to have sewer, water pipes or other connections and improvements constructed in advance of the laying of the pavement, but will reserve the right to open the street to perform such subsurface work during the progress of the work under this contract which in its judgment it may deem necessary.

No contractor should be obliged to bid on such an indefinite obligation.

In a recent case coming before the courts the specifications provided for a classification of excavation as "either common excavation or rock excavation." These were defined as follows:

> Common excavation shall include all material that can be removed with pick or shovel or by dipper dredge without blasting. Rock excavation shall include boulders exceeding 9 cu. ft. in volume and material requiring blasting for removal.

The contractors came upon sunken logs not expected by either party. These had to be removed by hand and cost the contractors more than twice what they were paid for rock excavation and more than twelve times what they were paid for common excavation. The War Department said that it could find no provision in the contract for paying them anything more than the common excavation price for this unusual condition. Contractors should be protected against such loose specifications as these by expressing in the general conditions that, where unexpected conditions are met, a reasonable allowance shall be made.

This association can render valuable service in co-operating with other organizations to secure more exact definitions of materials and more precise forms of specifications.

The Need for a Standard Form of General Conditions of Contract.—The American Institute of Architects has prescribed a form of general conditions of contract which is far in advance of any other form in recognizing the contractor's rights as an equal part to a contract. It is not too much to say that every other form in common use is so vague that it is within the power of the architect or engineer to make or break the contractor.

A standard form of general conditions should be framed by engineers and contractors working together and made a part of every engineering contract. It should be carefully prepared upon the principle of doing equal justice to both parties to the contract. There are two primary principles which should control in the preparation of such forms:

a. Proper responsibility should be assumed by each party in his appropriate sphere:

b. All disputed questions should be finally settled through the action of an impartial tribunal.

A form extensively used in contracts with the War Department contained the following provision violative of the first of the above principles:

> It is distinctly understood and agreed that the contractor assumes all risks under and in connection with the contract on account of delays in the work due to any cause.

In another government contract for public buildings the following provision occurred:

> That no claim shall be made or allowed for damages which may arise out of any delay caused by the party of the first part.

The party of the first part was the government and it actually delayed the contractor. The court before which the case came held, as it was obliged to do, that the contractor could recover no damages for delay caused to it by the United States. The injustice of these provisions cannot be denied, but they occur over and over again in public and private contracts and should be eliminated through the action of an organization like this.

At the present time it is usual to place responsibility upon the contractor for underground or underwater conditions. The owner makes some explorations and places these at the disposal of the contractor, but guards himself from responsibility by some such clause as this:

> The material to be excavated, as far as known, is shown by borings plotted on the drawings herewith (Sheets Nos. 11, 18 and 25), but bidders must inform and satisfy themselves as to the nature of the material. The United States will not guarantee the accuracy of its information.

Usually no time is left for the contractor to make explorations. If there were the cost would be prohibitive. Conditions are found very different from those represented by the borings and the contractor suffers a loss. The courts will give no relief save under exceptional conditions because, they say, the contractor had accepted the responsibility in signing the contract. It is entirely wrong to throw the risk for underground conditions upon the contractor. The site is the owner's and he should assume responsibility. He should make sufficient preliminary surveys through borings or otherwise to satisfy himself of the true conditions and these should be described and guaranteed by him. Thus the minds of the owner and contractor would meet upon a definite work to be done. If other conditions are found upon excavation the compensation should be increased or reduced.

"The Engineer's Decision Shall Be Final."—The contracts generally in use make the architect or engineer the final authority upon all question arising under building and engineering contracts. The following is a provision from a government contract:

> These specifications are intended to be full, clear and complete. Any doubt as to their meaning or any obscurity in the wording of them will be explained by the Engineer Officer, who shall also have the right to correct any errors or omissions in them whenever such errors or omissions become apparent. His decision in all such cases and upon all matters relating to the work shall be final and binding upon the contractor.

This is frequently justified on the ground that he is the author of the specifications and therefore the person best able to construe them. This very fact affords the best of reasons why he should not construe them. The engineer writes what in his judgment has a certain meaning; the contractor reads them with another meaning. The proper person to decide what the specifications mean is someone who is acquainted with the general subject-matter but whose mind is not already made up as to the meaning. The question for decision is not the intention of the author of the specifications when he wrote them; it is the intention properly conveyed by the expression used. There should in every instance be an independent tribunal created by the contract from which an appeal could be taken from every decision of the architect or engineer.

The standard documents of the American Institute of Architects, by way of contrast to the above, thus define the architect's rights:

> The architect shall have general supervision and direction of the work. He is the agent of the owner only to the extent provided in the contract documents and when in special instances he is authorized by the owner so to act, and in such instances he shall, upon request, show the contractor written authority.
>
> As the architect is, in the first instance, the interpreter of the conditions of the contract and the judge of its performance, he shall side neither with the owner nor with the contractor, but shall use his powers under the contract to enforce its faithful performance by both.
>
> The architect shall, within a reasonable time, make decisions on all claims of the owner or contractor and on all other matters relating to the execution and progress of the work or the interpretation of the contract documents.
>
> The architect's decisions, in matters relating to artistic effect, shall be final, if within the terms of the contract documents.
>
> Except as above or as otherwise expressly provided in these

[illegible]

The easy devolution of authority to the architect or engineer to decide all uncertainties directly encourages vagueness in writing specifications. If the engineer knew that the meaning of his specifications is to be determined not by himself but by independent authority, he would take every possible care to write the specifications with exactness.

Where the right to make final decisions is conferred by the contract upon the architect or engineers, and he decides erroneously, it is held by the courts that no correction can be made, even if he is wrong, no matter how much injustice may result.

Advantages of Uniform System of Cost Keeping.—Another method of eliminating risk arises in the adoption of proper systems of cost keeping. Here again is an instance where the skillful and efficient contractor is at a disadvantage in obtaining contracts. The inexperienced man underestimates his costs and his quantities, and thus underbids the efficient contractor and in the end loses money. Generally he has no proper acquaintance with overhead. The job is lost to the efficient contractor through this unnecessary competition with a possible profit at a reasonable price. Thus both are losers, while the owner, who has been struggling with a losing contractor, is equally dissatisfied.

I recall hearing a distinguished architect say that he considered one of his first duties to an owner was to see that he paid a sufficient price for his work, meaning that this is the only method in which a good job could be insured. An opportunity for extremely valuable work by this association is presented by instructing their inexperrienced competitors as to the meaning of overhead and by agitating for a uniform cost-keeping system, whereby it would be certain that every contractor had considered all the elements of cost before making his bid.

A manufacturer doing a large business in a common building material in a middle western city told me that he had found it to his advantage to publish a pamphlet containing his entire cost system and to employ capable men to go about among his competitors and explain to them the advantages of cost keeping on this basis.

The result of eliminating the risk as far as possible from construction work is not alone for the benefit of the contractor. Whatever unnecessary risk the contractor assumes must ultimately be included in the cost which the owner pays. There is no other paymaster but the owner. Contractors cannot live without charging a percantage, payable by the owner, to cover unnecessary risk. This becomes a part of the ultimate actual cost. By such risks owners would be relieved of such additional charges and would obtain rock-bottom prices based upon actual work and a complete understanding of the work to be done. Besides this competition would be increased. Yet the contractors would be greatly benefited because the ever-present fear of loss would be measurably reduced.

No contractors' organization in this country has ever been placed upon a sufficiently firm basis to permit it to undertake these movements for the benefit of contractors as a whole until the organization of this association along broad lines, with sufficient financial support to insure beneficial results to the entire body of contractors of the United States.

Civil Service Examination for Assistant Engineer.—The U. S. Civil Service Commission announces an open competitive examination for assistant engineer. A vacancy in the Engineer Department at Large, Chattanooga, Tenn., at $4,000 a year, and vacancies in positions requiring similar qualifications, at this or higher or lower salaries, will be filled from this examination, unless it is found in the interest of the service to fill any vacancy by reinstatement, transfer, or promotion. The duties of the appointee will include supervision of the preliminary report of the survey of the Tennessee River covering the potential development of its water resources, including navigation and the relation to navigation of possible hydroelectric development, flood protection, water supply, etc., and the extent to which such development would affect the United States, the states, municipalities, and private interests. Applications must be filed before March 15.

River Control by Wing Dams

An interesting description of bank protection work which was carried out during the past two years in British Columbia was given by Mr. R. W. MacIntyre, of Victoria, B. C., in a discussion of a paper submitted by W. C. Curd to the American Society of Civil Engineers. The notes following are taken from Mr. MacIntyre's discussion:

The Capilano River, with a drainage area of 64 sq. miles. rises among the lofty peaks of a mountainous peninsula lying directly north of Vancouver, B. C., Canada, at a head-water altitude of between 1,500 and 1,600 ft., thence following south for 20 miles to the mouth, where it discharges into Burrard Inlet, an arm of the Pacific Ocean. The Pacific Great Eastern Ry. crosses the Capilano River about ¼ mile from its mouth, and early in 1918 it was decided to replace the existing trestle bridge with two 100-ft. through Howe truss spans, at the same time raising the rail level 10 ft. above the original elevation, in order to eliminate the trouble caused by flood discharge carrying down trees, logs, and driftwood, which had hitherto periodically swept away the trestle bridge during high water.

The main problem to be solved in connection with the new bridge and grade was how to control the river which had widened its channel to about 900 ft. at the bridge site, although the normal width of the water surface, when confined in one channel and clear enough for fishing with rod and line, would probably not exceed 100 ft. The measured flow of this stream during the past five years gives a maximum discharge of 9,620 cu. ft. per second in April and a minimum of 35 cu. ft. per second in September, but both figures may be considered to be abnormal, the average extreme flood discharge running between 2,000 and 3,000 cu. ft. per second, with low water from 50 to 100 cu. ft. per second. It was fully realized, however, that the new bridge and approaches must be designed to withstand the most extreme conditions recorded in the past or possible in the future.

The geological formation of the bed of the Capilano River presents serious difficulties for obtaining good foundations, consisting of gravel and large round boulders of undoubtedly glacial origin, for an indefinite depth. On this the hydraulic force of the river exerts a "digging" action which was given practical demonstration during 1917 when the east span of the Marine Drive Highway Bridge collapsed, owing to the undermining action of the river in the abutment foundation. This is a highway bridge of reinforced concrete, consisting of four 70-ft. arches, and was built by the municipality in 1914; it is less than a mile up stream from the Pacific Great Eastern Railway Bridge and is referred to here because river conditions at both bridge sites are exactly similar, identical methods having been utilized for protection work.

The contract was let in April, 1918, for a bridge consisting of two 100-ft. through Howe truss spans supported on a center pile pier, with a pile abutment at either end, both substructure and superstructure being of the standard type usual for this class of railway bridge, and pile-driving was started during same month. Some delay was encountered in the erection of the superstructure, owing to the falsework being carried out by a sudden freshet, but the bridge was opened for traffic on Nov. 7, 1918.

Nearly all the piling pulled out in connection with the removal of the original trestle, was found to have "broomed" at the points. The average "refusal" depth of the piles driven on the new work was about 6 ft., with a maximum of 10 ft., but in such a river-bed formation it is doubtful whether any pile was driven beyond 6 or 8 ft. without "brooming", although shod and ringed.

Details of Log Wing Dams.—When construction was started in April, the main channel of the Capilano River hugged the west bank which was found to be rapidly eroding and, consequently, endangering the fill at the west end of the bridge toward which the flow of the river was directly working. To remedy this condition three log wing dams (or groins) were built about 400 ft. apart, up stream from the bridge, and approximately at right angles to the current; the dimensions were about 18 ft. long by 6 ft. high and 4 ft. wide, each crib resting on a brush wire mattress. The principle involved being flexibility as opposed to rigidity, may be explained as follows: A brush mattress is first made from ordinary No. 9

wire fencing (such as is used for right of way [illegible] live green tree limbs, willows, or any suitable brush in leaf, laced in and out between the strands; this is sunk to the bed of the channel as a foundation for the cribwork which is built up similarly to a log shack, except that the timbers are wired together with No. 8 or No. 9 telephone wire, and drift-bolts are driven where required.

Before filling the cribs, the wire fencing is dropped inside to form a loop with the ends projecting above the sides, and loose brush is laid in the bottom of the crib (on the wire fencing), this being covered with gravel and boulders up to the level of the crib top. The shore end of the crib sides should be dug into the bank for 2 or 3 ft. and protected with a wire and brush mattress at the up-stream side, from top to bottom. The height of the crib is governed by high-water flow which should have a depth of from 18 in. to 2 ft. above the top, to avoid impact from floating logs and other detritus.

Action of Wing Dams.—The action of the wing dams is to cause a strong eddy which carries in gravel and boulders behind the cribwork, forming a bar, and in the writer's experience this constitutes the best type of protection, as a river seldom digs out bars of its own, under normal conditions. As a general rule, the up-stream toe of the crib undermines more or less during high water, causing it to cant over at any angle, and the cribs built on the Capilano River proved to be no exception, but, being flexible, adapted themselves to the new position while the brush and wire beneath the filling followed the subsidence down, checking further undermining; one wing dam crib, exposed to the full force of the current at a bend in the river, was undermined at the up-stream face to such an extent as to tilt forward 60° from the vertical, but without developing any lateral movement. In this case, a new crib was built up behind the original structure which now acts as a foundation protection, effectually preventing erosion beneath the toe. Within a few months of construction the wing dam cribs had built up a solid bar along the west bank of the river which then changed its course to the opposite bank, threatening the fill at the east end of the bridge and emptying the east abutment by scouring beneath the sheeting. Prompt action being necessary to meet this contingency, continuous loops of wire fencing were dropped inside the empty abutment, followed by a heavy layer of green brush on which loose rock (train-hauled) was dumped to complete the filling; in addition to this, a brush wire mattress was woven and sunk vertically down the nose of the abutment, the ends being swung into place along each side by the force of the current.

Similar methods were adopted at the center pier, which was undermined and emptied shortly afterward, the river also scouring out a hole 16 ft. deep immediately behind it, which was filled as follows: A wire brush mattress was sunk for a foundation and was followed by heavy loose rock filling 5 ft. in height, wire fencing laid on top completely covering the surface of the filling; the second layer of loose rock and boulders for the next 5 ft. was also covered with wire fencing, and the final 6-ft. section, bringing the fill level with the river bed, was mattressed about 18 in. below it.

In addition to this work on the piers, the east bank was mattressed for a distance of 900 ft. up stream, as the current was commencing to find a new channel through the river flats which lie at an elevation of from 8 to 10 ft. above low-water level; all the work, as described, has been subjected to the most severe flood tests during the past 1½ years without showing any sign of erosion. The use of plain wire fencing in connection with gravel and boulder filling for wash-outs, cribs, etc., has proved remarkably effective both in checking erosion and providing a stable foundation base for the extension of the protection work when required, as the fine silt deposited during high water rapidly fills in all the voids, forming a solid mass which is impervious to the destructive "digging" action of the river. Similar wing dams composed of gravel and brush only, owing to the scarcity of timber, have been built on prairie streams under the writer's supervision with satisfactory results, but in every instance the channel bed formation consisted of gravel and boulders in which tests made during flood discharge established the fact that a down-stream movement was perceptible in the gravel for a depth of several feet below its surface. It is this feature which constitutes the greatest menace to bridge foundations, as any rigid structure (such as a pier) forms an obstruction providing the necessary leverage to set up gyratory action wherewith the hydraulic force of the river bores downward, finally undermining concrete substructures or digging out the piles in timber construction. In theory, the engineer is supposed to lay out his work so that excavation will be carried down until a stable foundation is assured, but this discussion is designed to show that alternative methods are both feasible and practical, especially when the amount of expenditure is limited.

Essential Points in Use of Wing Dams.—In conclusion, it may be stated that while no hard and fast rules can be laid down for this class of river-protection work, there are a few essential points which should not be neglected, namely:

Wing dams should not be too long, as this prevents the "eddy" from carrying material inshore to the bank; a length of crib of from 16 to 20 ft. will start a good bar, and when this is built up the wing dam can be lengthened in sections to continue the same operation. The height should be carefully regulated to allow for a depth of from 1½ to 2 ft. of water flowing above the top logs at flood stages of the stream.

Flexibility being the underlying principle in this type of protection work, the logs should be held together, both vertically and horizontally, with several strands of twisted No. 8 galvanized wire; drifts should be used as little as possible, owing to their tendency to split the logs when the crib becomes distorted from undermining.

An inside width of about 4 ft. is sufficient for the first section as extensions are added by the logs overlapping on the outside thus widening the crib as each new section is built on.

The selection of strategic points at which to place the wing dam cribs is a matter of judgment based on a careful study of conditions, and as the construction has to be carried out at low-water stage the engineer should be ready personally to observe the action of the stream during the first high water, in addition to the after effect when it has lowered sufficiently to expose the cribs, etc. It will then become evident whether these are properly located or working to advantage, and changes or additions can be made in accordance with the results revealed.

This class of work closely resembles a game of chess in which the river is constantly making new moves and calling "check", while the engineer responds with counter moves backed by the definite object of being able to say "checkmate".

Magnetic Analyses for Detecting Imperfections in Steel Rails

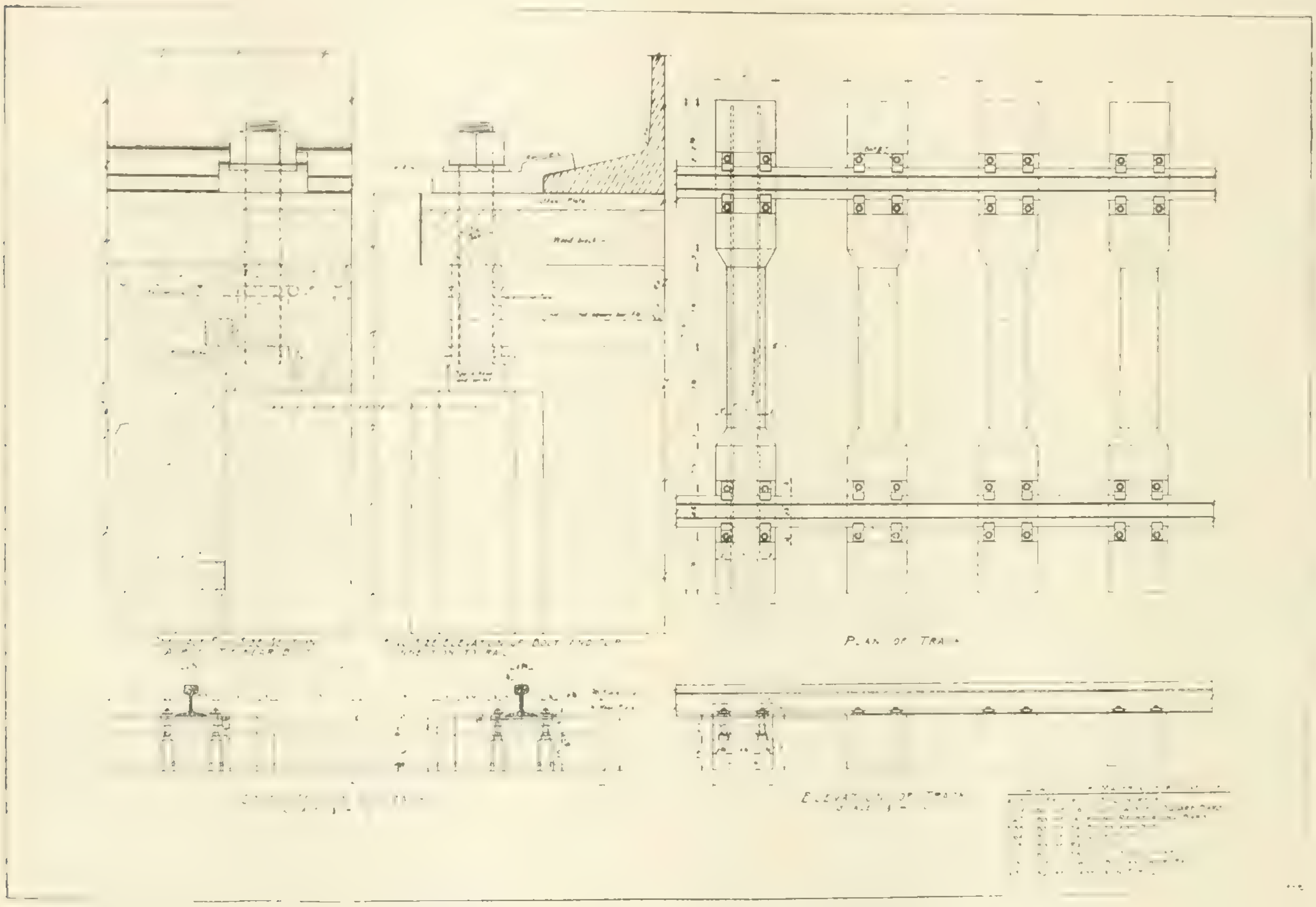
Through the efforts of several steel experts who recognized the great practical value and immense possibilities of magnetic testing to the metallurgical industry, an apparatus has been perfected and placed on the market, according to the Electric Railway Journal, which enables one to establish the relation between the magnetic and mechanical properties of steel and detect imperfections. Such an apparatus, called the Burrows magnetic analyzer, is now obtainable from Holz & Co., New York.

The principle on which this analysis is based is that there is but one set of mechanical conditions corresponding to every set of magnetic characteristics. There are two separate analyses made, one using a magnetoscope, which gives information about the composition and mechanical and heat treatment of the specimen, but does not give any indication of the existence of flaws, and the other, the defectoscope, which determines whether non-uniformities exist, but does not indicate whether or not a specimen is hard or soft. The analyzer consists of a magnetizing solenoid wound on a brass tube, inside of which is a test-coil unit conforming as nearly as possible to the section of the specimen. The unit consists of two coils of fine wire having an equal number of turns and connected with ballistic effects opposed. This outfit, which surrounds the specimen, is driven at a constant speed along it and whether used to analyze quantitatively or to detect imperfections depends on the connections and circuits, for which two separate control boxes are furnished.

Magnetic surveys and analyses, it is claimed, will furnish information impossible to secure by any other means of testing. The fact that materials can be tested without destruction is of prime importance, and it is this feature of magnetic analysis which makes it possible to find in advance those rails which, after injury under straightening presses, would develop in service a complete interior transverse fissure. It is also suggested that this test would eliminate the occasional defective rail before it leaves the mill or is put in the track.

A New Reinforced Concrete Railroad Tie

A new railway tie, the invention of A. C. Rapelje, Senior Highway Engineer, U. S. Bureau of Public Roads, is shown in the illustration. In this invention the rail fastener is the special feature on which a patent has been awarded. It will be noted from the sketch that the bolts are readily removable in case of breakage or for the insertion of bolts of greater or less lengths for a purpose to be explained later on. It also will be observed that these bolts are entered by a side opening or slot, which extends from the base of the tie to a point about one-half the tie thickness.



Details of New Reinforced Concrete Railroad Tie.

The upper half section of the tie and centered directly over the slot is a moulded-in cast metal square-headed socket in which the bolt is inserted; above the sockets rests a section of either fibre or creosoted wood block and above this the metal plate on which the base of rail rests. These bolts pass through the sockets, the fiber or wood block and the metal plate. The principle exerted is to hold the lower half section of bolt firmly in the socket and the upper half is allowed a certain amount of play or spring between the sides of the fibre or wood block, metal plate and the concrete shoulders of the tie. In this way some elasticity of value is given to the whole mechanism of rail fastening. By the use of this method, it is claimed that the track that becomes "heaved" by poor drainage and frost action, can readily be shimmed up or down to reduce jolts by inserting bolts of greater length and temporary shim blocks, or, working the other way or both, by reducing the length of the bolts and lessening the thickness of the normal sized fibre or creosoted block. Should a bolt become broken at any time, the lower broken section will drop down in the slot and the upper broken section being released from its holding pressure, will lift and become out of position sufficiently to call the attention of the trackwalker to its condition.

A liberal amount of reinforcement is allowed to protect the metal sockets from breaking out under the strain and pull of traffic and the expansion and contraction of the rails. It is realized that should a tie become cracked through in its narrower or central portion, it would not mean the spreading of the rails or the discard of the tie, as the four reinforced metal bars would hold the same in rigid position for some years of service.

The shape of the tie is such as to give a uniform and wider rail base surface than is possible with the wooden tie; likewise advantages will obtain in a more uniform tamping whether by hand or machine due to this uniformity of width. It is also claimed that the tie would effect a very large reduction in ties per mile. Taking the standard practice of 20 wooden ties to the 30-ft. rail, but 15 of the concrete ties of this standard will be required to give an equal amount of rail bearing surface and spacing. This means a saving of 880 wooden ties to a single track mile.

Ties of this type when used for sidings, yards, branch lines and electric urban and suburban use may be moulded in lighter section with but one rail fastening on each side of the rail staggered.

The tie as shown in the sketch is designed for heavy main line service. As to gage, the question may be asked, how to take care of the varying gage between the standard 4 ft. 8½ in. and the widening on curves as standard practice in use by railroads using such gage. With the Pennsylvania Lines, standard gage is 4 ft. 9 in. irrespective of curves, except at extreme degrees of curvature some concession may be made in widening the gage. This feature on railroads carrying the 4-ft. 8½-in. standard and going up to 4 ft. 9 in. on curves, may be provided for in a different sized clip or fastener of different shape to identify them from the tangent fasteners and to provide ¼-in. excess gage on each rail.

As for any complications arising at the rail connections due to splice bars, these may be repunched with an opening of sufficient size to permit the fastener to rest on the rail base, or a special size fastener to rest over the top of the splice bar may be provided.

Statute of Employment Relations for Construction Industry

In its report presented Jan. 26 at the Second National Conference of the Associated General Contractors of America, the Committee on Labor embodied a fundamental document called "A Constitution of Industrial Relations," which contained principles applicable to all employment in every industry. This document was supplemented by "Statutes" designed to be a general statement of right employment relations in the construction industry. The Committee on Labor of the association consisted of Leonard C. Wason, chairman, of the Aberthaw Construction Co., Boston, Mass.; H. J. Brennan of W. E. Wood Co., Detroit, Mich.; Tylor Field of the Ferro Concrete Construction Co., Cincinnati, O.; G. O. Muhlfeld of Stone & Webster, Boston, Mass.; F. W. Smith of the Walsh Construction Co., Cleveland, O., and C. P. Waterman of J. H. Grozier Co., Hartford, Conn. The report of committee was approved by the convention. The "Constitution" was made public last June and was reprinted in the July 21 issue of Engineering and Contracting. The "Statute of Employment Bulletin" follows:

I.—Employment.—(1) The value of a good spirit in an organization is vital to successful industry. The organization may think favorably or unfavorably of its employers, may work with enthusiasm or without any, depending upon what the individual thinks of his employers and the work they are doing. Therefore, there must be frankness between employer and employe, perfect freedom in action and expression of thought, to maintain mutual friendly relations.

(2) When hiring an employe, a complete record of his experience should be obtained. He should be fully informed of the conditions of his employment, wages, hours, location, living conditions, dangers, etc., and the methods of his employer and what he expects of his employe. That is, there should be frankness, mutual confidence, and respect on both sides from the start. Continuous efforts must be made to advance and increase these mutual relations in order to prevent or adjust misunderstandings as soon as they are discovered.

(3) The fact is recoginzed that in many locations and establishments, the basic 8-hour day, or a weekly equivalent, has been adopted as the usual standard. As the number of hours properly constituting a day's work varies in some locations and classes of construction work, it is recommended that changes from the usual standard be so made as not to disrupt or disorganize the rest of the industry.

(4) Overtime work should be discouraged. Where the nature of the work is such as to require employes to work beyond the established hours, they should receive an extra rate of compensation for such overtime.

(5) Continuity of employment is desirable and should be maintained as far as possible.

(6) Apprentices should not be limited in number in any trade. If equitable rules as to the period of service and the degree of skill required of apprentices are made by the various trades, the law of supply and demand will regulate the number.

(7) Discrimination against the use of apprentices by organized labor must not be permitted. Employers in large communties should encourage the establishment of public trade schools and the attendance of the youth at them.

II.—Working Conditions.—(1) The public interest and the comfort and health of individual employes demand that every effort should be made to perfect the conditions of employment, with special reference to sanitary conditions, heat, light, ventilation; safeguarding the health of workers and providing protection against, and treatment in cases of accidents; suitable rest periods where necessary; and due warning to the worker if he is undertaking to peform a hazardous operation.

(2) Provide safety devices and guards against accident and disease. Mechanical plants, stagings, ways and works should be inspected daily. Where temporary camps are used, provide proper inspection for sanitation, food supply, water, and the welfare of the men.

(3) Employes should be safeguarded against unjust treatment or arbitrary discharge by their foremen or immediate superiors. In justice to employes, adequate advance notice should be given, whenever possible, to those who must necessarily be laid off. Likewise, an employe should give reasonable notice to his employer of his intention to leave the service.

(4) The temperament of the gang boss or foreman in direct contact with the hand workers is most important. He must be fair and give his men a square deal.

(5) Establishment by conference between the parties, what facts concerning the company's and men's activities should be common knowledge to both, and provide for giving these facts fullest publicity.

(6) All states should enact compulsary workmen's compensation insurance laws that are just both to the employer and employed.

III.—Production.—(1) Public interest requires increasing output per man as a prime factor in reducing construction costs.

(2) Employes should not, therefore, intentionally restrict individual output to create an artificial scarcity of labor as a means of increasing wages or continuity of employment, or of equalizing the productivity and wages of workers having different degrees of skill and ability. Employes should also co-operate with the employer in the adoption of new and improved machinery and methods with a view to increasing efficiency, thereby lowering the cost of construction.

(3) The value of industrial training as a means of increasing production is recognized. Such training should be encouraged by employers and employes.

(4) The reduction in working hours below the economic limit in order to secure greater leisure for the individual should be made only with full understanding and acceptance of the fact that it involves a commensurate loss in the earning power of the workers, a limitation and a shortage of the output of the industry, and an increase in the cost of construction, with all the necessary effect of these things upon the interests of the community and the nation.

(5) As an incentive to greater production, make provision for increasing compensation whereby men of extra skill and knowledge may add to their regular wage.

(6) Make some expression of appreciation, by word or letter as reward for duty well done.

(7) Make an incentive to extra effort for production by promotion where possible for those who prove worthy.

IV.--Right of Association.—(1) The association in groups of employes not affiliated with an organization of non-employes should be encouraged. The right of employes to organize into trade unions is recognized.

(2) Employes should not require of their employer that employment be conditioned on membership or non-membership in a trades or labor union. Employes should not coerce fellow-employes to join, or refrain from joining, a trades or labor union.

(3) Freedom of contract of employment must never be impaired. However, employers should not so exercise this right as to discriminate in the employment or discharge of employes on the ground that they are, or are not, members of a trades or labor union.

(4) Means should be devised to create public sentiment in favor of these principles and to keep the community informed of all action at variance to them.

(5) Capital, employers and employes should be subject to law and its processes with equal facility. Special legislation which may benefit either to the possible injury of the other, or to the possible injury of the consumer, is detrimental—and a consequent menace to the community.

V.—Adjustments of Disputes.—(1) Adequate means, satisfactory to both employer and employe, and voluntarily agreed to by them, should be provided for mutual discussion and adjustment of employment relations.

(2) Where the channel of communication existing between an employer and and the individual employe does not offer employes suitable means of negotiation with their employer, the employer should seek to establish mutually satisfactory means. For this purpose representative negotiation is advocated.

(3) Representative negotiation is defined as that form of collective bargaining which provides for negotiation between an employer and duly accredited representative of his employes, regarding hours, wages, and all other matters properly affecting their relationship. Employes' representatives should be duly accredited, should be chosen by the employes, from among their own number unless otherwise agreed by employer and employes, and be empowered by the employes to negotiate for them. Such negotiation should be under control of the parties immediately concerned and should they fail to reach an agreement, the employer and the group of

employes' representatives should [illegible] of choosing, without restriction by the [illegible] responsible and competent advisor or advocate to meet with them in the continued negotiations. Representatives of employes, selected by and from among their own number, should be assured by their employer that no discrimination will be made against them because of anything said or done in their representative capacity.

(4) As it is often impractical, owing to the nature of the industry, for a single employer to reach a final conclusion with his own employes, a group of employers should negotiate with a group of employes. Such group negotiations should be conducted as far as possible in accordance with the plan of representative negotiations above outlined.

(5) Nothing herein is intended to abrogate the right of an individual employe to negotiate directly with his employer.

(6) Employers and employes should uphold in their integrity all arbitration awards or agreements entered into between them.

(7) While the employer and employe may reach a settlement of their individual relations without reference to outside aid, this solution may affect the rest of the industry, locally, as well as the interest of the public, which is paramount. Therefore, the public's representatives ought to have a right of review of a settlement to ensure that its interests are protected. The interests of the public in reviewing adjustments of industrial relations can be well performed by the establishment of Industrial Courts.

(8) There must be no coercion by either party toward the other. Public sentiment should support all public officials in enforcing the laws in respect to these practices.

(9) The fact should be recognized that both employer and employe are servants of the public, that every disagreement adds to the cost of living and that the final judge in all disputes should be the public. The public should give expression to its views through a board of advisers whose decision should be recognized by both parties as final. Disputes, ill feeling, and discord invariably fade, once the facts are aired and given to the public.

Rapid Rail Bonding

A description of equipment for rail bonding is given in a recent issue of the Electric Railway Journal. Unusual speed was attained by drilling with two air-operated drills, the two ⅞-in. holes required in the web of each rail for the rail bond. The compressor was an "Imperial" Ingersoll-Rand type on a four-tool compressor car, originally designed for operating tie tampers. Two air tanks, 16 in. x 48 in., were added to this outfit in order to secure a more uniform pressure and better engine operation. While the drills were operating an air pressure of 55 to 60 lb. was maintained at the reservoir of the compressor which furnished power for two drilling motors.

The drilling machines were close-quarter drill motors, mounted on a frame consisting of two 1¼-in. pipe guides extending from rail to rail. These were separated at the ends by two clamp plates of sufficient depth to prevent the frame from slipping over the head of the rail. The drill motor was supported between the guides by two transverse plates separated by sleeves which slide on the pipe guides. The drill feed consisted of a long lever with a gear segment acting on a rack. A downward pressure on the lever forces the whole carriage along as the drill bores through the web of the rail. The whole frame was supported on four set-screws, one in each corner, resting on the head of the rail and furnishing a means of adjustment and leveling the frame.

With an outfit of this type a hole can be bored in an average rail in about 25 seconds, but in harder steel it often takes 40 to 50 seconds. Some difficulty was experienced with extremely hard steel in the rails. It was found necessary to use care in selecting the drill bits, otherwise there was considerable trouble due to breakage and difficulty in regrinding. One man was retained at the shops for regrinding drills, which operation required careful attention in order to secure bits which would give uniform diameter of holes.

The drill motors were connected to the compressor with a 50-ft. and a 75-ft. section of ¾-in. armored air hose. With this hose each drill could work on two joints for each movement of the compressor. To clear the track for train movements the air compressor was jacked up and rolled clear on skidways. The average bonding rate was about 80 per hour, and as many as 110 have been placed in an hour. The best record was 629 bonds in seven hours and 20 minutes' drilling time. The actual drilling time averaged about 5½ hours per day, the lost time being due to going to and from work, clearing the track for trains, etc. This time would vary considerably with other working and traffic conditions. For one compressor the usual bonding crew consisted of 21 men, including the foreman, drillers, helpers and others required for the complete bonding operation.

Fighting Snow on an Electrified Railway

Mr. Arthur C. Carty, writing in Electric Traction, has given some experience acquired on the London and Port Stanley Ry. in Ontario, and emphasized some of the advantages of electrical operation with special reference to fighting snow. The following is quoted from his article:

Before the electrification of the L. & P. S. Ry., the writer has seen that road stormbound for the better part of a week; with five or six Pere Marquette and Michigan Central locomotives dead in a 5-mile stretch of track; standard steam road plows unmoved by three enfeebled steam locomotives, with fires killed by melting snow; and disgruntled passengers stranded in nearby farmhouses arranging unwelcome sleigh ride parties back to the city.

Since electrification the L. & P. S. Ry. has never operated fewer than 12 trains a day over its most troublesome section. The one day on which that low level was reached saw the worst storm in memory—a continual blizzard in January, 1918, that left steam railroads of both the United States and Canada paralyzed for a week. But throughout that storm the L. & P. S. Ry. kept open, and accepted for transfer the passengers of the stormbound trunk steam railroads.

The principle snow fighting equipment on this road is an ordinary steel nose plow, driven by an 800-H.P. 60-ton locomotive. During the first couple of winters it was the practice to attach a plow directly to the locomotive. That entailed about three hours' work, the attendant delay, and the withdrawal of the motor from service while the work was performed. Now nose plows are attached to each end of a flat car, weighted with 30 tons of rails. The car springs are removed to eliminate a tendency to climb. The flat car is equipped also with wings to spread the snow, and the cab following the locomotive carries a set of flangers. This battery ordinarily maintains a speed of 20-25 miles an hour through snow up to 2 ft. deep and throws it back to, or beyond, the right-of-way fence.

Drifts slacken the pace, but it has never yet been found necessary to put more than one lomomotive on a plow. Cuts to a depth of 6 ft. have been made at 5 miles an hour, under conditions that would have taken the heart out of steam motive power. In cuts where snow has drifted to abnormal depths it has been found necessary to draw back and run into the bank repeatedly. That is the work in which the drivers of the steam locomotives used to slip and stall; but the electric motors deliver a steady flow of power, at full efficiency, to every axle, and slipping is seldom known.

Railroad operators generally agree that about the most perilous job men can be given is manning a plow that is made the nose of a battering ram driven by two or three locomotives. Plows in that service have been wrecked and crushed and death or maiming has been the fate of workers. On the L. & P. S. Ry. equipment, the workers are not endangered.

The flanger operators are safe in caboose behind the locomotive. With a plow on each end, and the switches open, the locomotive can be run around the flat-car equipment, and the battery quickly remarshaled for operation in the reverse direction from any part of the line.

The spreader wings on the plow car have been found especially useful in cleaning up the yards, where snow can be quickly shoved across from track to track and at length clear of the right of way. Through the open country they have a more restricted usefulness. When drifts cover and fill the snow fences, it is usually necessary to employ shovel gangs to widen the trough cut by the plow, and haul the snow away.

The L. & P. S. Ry. has kept its mechanical troubles to a minimum by occasionally sending locomotives into the warm shops after a couple of trips on snow plow service. When snow fills the resistance grids and accumulates in places where troubles may result the thawing . . . a profitable "stitch in time."

The same holds true for passenger motor cars where . . . is the difficulty. When heavy ice coats the power wire it is the custom to send out two-car trains with all four pantagraphs up. The first usually shatters the ice, but collects no power; the second continues that operation and may furnish a little energy, but the third and fourth can be depended upon to find a bare spot and keep the wheels moving. The ice has on a few occasions formed so heavily on the pantagraphs as to bear them down against the air pressure, thereby weakening their capacity to scrape the wire. In that contingency such cars are relieved from service and sent to the barns for an hour's thawing out.

The Chicago, Milwaukee & St. Paul Ry. has now adopted a snow-proof motor housing that was developed on the London & Port Stanley Ry. The L. & P. S. Ry. passenger cars are equipped with ventilated type motors through which a current of air is drawn in operation. The motors developed trouble each winter, due to the melting of snow on the armatures. The crippling of motors became such a serious problem that immediate steps were necessary to eliminate the trouble. Accordingly, there was devised galvanized iron housings to enclose the vents through which the snow entered. The manufacturer's engineers gave warning that overheating troubles would follow, but the road's management took a chance. It ended the old trouble and produced no new ones, as winter temperatures furnished all the cooling required. The test was followed with interest by the manufacturers of the motors and the idea, as stated, has now been passed along to the St. Paul electrification, where an identical problem had been encountered.

Portland Cement Production in 1919 and 1920

In the production, shipment, and gross value of Portland cement, 1920 was a record year, according to estimates prepared under the supervision of Ernest F. Burchard, of the United States Geological Survey, Department of the Interior. The production is estimated at 100,302,000 bbl. and the shipments at 96,329,000 bbl., valued at $193,548,000, compared with 80,769,378 bbl. manufactured and 85,596,616 bbl., valued at $146,656,076, shipped in 1919, an increase of 24 per cent in production, 13 per cent in shipments, and 31.9 per cent in value of shipments in 1920. The stocks of finished cement increased from 5,852,497 bbl. at the end of 1919 to about 8,290,000 bbl. at the end of 1920, or more than 41 per cent. The average factory price in bulk at the mills for the whole country was $2.01 a barrel in 1920, compared with $1.71 in 1919, an increase of 17.5 per cent.

The statistics for 1920 include reports from practically all manufacturers of Portland cement and are based on records for the first 11 months plus estimates for December. Some of the estimates for December may have been too large, so that when the final returns for 1920 are received the actual production and shipments may prove to be slightly lower and the stocks on hand slightly greater than the figures here given.

There were 115 plants that manufactured Portland cement in 1920, compared with 111 active plants in 1919, one additional plant each having operated in Alabama, Indiana, New York and Oregon.

The accompanying table shows by districts the shipments in 1919 and 1920.

District.	Shipments 1919 Quantity (barrels)	Shipments 1920 Quantity (barrels)	Average factory price per barrel. 1919.	Average factory price per barrel. 1920.
Lehigh district (eastern Pennsylvania and New Jersey)	23,501,560	24,984,000	$1.64	$1.91
New York	4,441,250	6,049,000	1.73	1.98
Ohio and western Pennsylvania	7,102,442	6,947,000	1.71	1.94
Michigan and northeastern Indiana	5,459,439	1,920,000	1.70	2.44
Southern Indiana and Kentucky	2,640,556	3,083,000	1.67	2.06
Illinois and western Indiana	9,932,158	12,109,000	1.62	1.77
Maryland, Virginia and West Virginia	2,613,963	2,911,000	1.73	2.09
Tennessee, Alabama and Georgia	2,830,588	2,580,000	1.75	2.21
Iowa, Missouri and Minnesota	11,440,614	11,593,000	1.69	1.93
Nebraska, Kansas, Oklahoma and central Texas	6,292,712	7,981,000	1.84	2.02
Colorado, Utah, Montana and western Texas	2,982,012	3,718,000	1.99	2.20
California, Washington and Oregon	6,359,226	9,124,000	1.92	2.36
Total shipments and average prices	85,596,616	96,329,000	1.71	2.01

Renewal of Overhead Construction in the Hoosac Tunnel

The Hoosac tunnel, in western Massachusetts, on the Boston & Maine Ry. system still retains the distinction of being the longest mountain tunnel in the United States. For many years the traffic through it has been heavy so that about 10 years ago it was finally electrified. The traffic has kept on increasing, and owing to the fact that the steam locomotives are towed through the tunnel it has been found that the injurious gases escaping are sufficient in quantity to have caused considerable corrosion in the catenary construction overhead. Recently part of this overhead construction has been renewed as is described in the Railway Electrical Engineer, from which the following is taken:

The new catenary messenger wire or cable differs from the original in that it is covered with a single braid of impregnated cotton. This cable was supplied by the Standard Underground Cable Co. and the weatherproof braid with which it is surrounded is intended to prevent a re-occurrence of the same trouble which so shortened the life of the previous cable. Furthermore, the trolley hangers which are clamped firmly to this messenger wire are hooked over the outside of this braid, the only contact surface exposed being a small portion of the cable on the underside upon which the clamp presses. This unique construction detail has been adopted with the idea of preventing, if such a thing is possible, a reoccurrence of the trouble which was experienced with the former cable. In addition to the braid covering over the messenger cable a coating of black enameled paint has been applied. This paint not only has been used to further protect the messenger cable but has also been used on the hangers and the trolley wires as well. It is hoped, to some extent at least, it will eliminate the corrosion which was experienced with the first installation. Just how often it will be necessary to paint this cable, hangers and trolley wires is a matter of conjecture, but if it proves that the painting periods are not too frequent it is obvious that it will be far cheaper than to be obliged to renew the entire overhead equipment.

The present traffic through the tunnel amounts to about 100 movements per day, and the electrical operation is so much more satisfactory than the steam that the difference is very striking in many ways. It is said that now one may stand in the center of the tunnel and see the daylight at either portal. A partial description of the difficulties of the old steam operation are quoted from the above mentioned journal. Years ago the tunnel was equipped with electric lights and was featured in the advertising literature of the company. As time went on, the traffic through the tunnel increased and the quantity of smoke and gases emitted by locomotives passing through dimmed the electric lights until eventually they were abandoned. Each succeeding year brought increases in traffic with the conditions growing worse and worse.

The construction of the tunnel is such that there is a slight grade upward from each portal to the center. Normally there would be no necessity for a helping locomotive, but the rail conditions in the tunnel are so bad and so much trouble was experienced that helping locomotives were provided for trains in both directions. Now and then an engineman would attempt to go through the tunnel without assistance provided conditions were favorable, but for the most part the men were so affected by the difficulties of the run that they could not be induced to make the attempt alone. It must be said that their fears were justified, for on many occasions enginemen and trainmen were so overcome by smoke and gas as to require hospital treatment. So bad were the rail conditions, that it was quite a common thing for an engineman to hold a broom handle against the tunnel wall to ascertain whether or not his locomotive was moving. On one occasion, an engineman of a passenger train was so deceived by the sound of the exhaust and motion of the locomotive that he allowed the driving wheels to slip until he was signalled from an official on the train who had discovered that the train had stopped. The driving wheels had slipped so long that the head of the rails were practically worn through and the tires on all of the drivers loosened.

Conclusions and Recommendations of the Federal Electric Railway Commission

In May 1920, President Wilson appointed a commission to investigate and report upon the condition of the electric railways of the country. Its personnel included utility managers and other officials, representatives of employes, bankers, and students of street railway problems; and its report rendered in August, 1920, was unanimous. The report was comprehensive, and was based upon elaborate studies of data as well as upon the personal testimony of 95 witnesses.

The problem before the commission was stated in a joint letter from the Secretaries of Commerce and of Labor as follows:

"Large systems are on the verge of insolvency, for the industry as a whole is virtually bankrupt. The continued shrinkage in the values of hundreds of millions of electric railway securities held by savings banks, national banks, life insurance companies, and by the public at large threatens to embarrass the nation's financial operations. Furthermore, the withdrawal of this industry's buying power, which is said to rank third in magnitude, involves the unsettlement of collateral industries, naturally entailing labor dislocation that will affect hundreds of thousands of employes."

The Commission's conclusions follow:

1. The electric railway furnishing transportation upon rails is an essential public utility and should have the sympathetic understanding and co-operation of the public if it is to continue to perform a useful public service.

2. The electric railway has been and will continue to be a public utility, subject to public control as to the extent and character of the service it renders and as to the rates it charges for such service.

3. It is of the highest importance that both the total cost of the service and the cost to the individuals who use it shall be kept as low as possible without injustice to those who take part in producing it.

4. The electric railway industry as it now exists is without financial credit and is not properly performing its public function.

5. This condition is the result of early financial mismanagement and economic causes accentuated by existing high-price levels of labor and materials, and of the failure of the uniform unit fare of 5 ct. prescribed either by statute or by local franchise ordinances or contracts to provide the necessary revenues to pay operating costs and to maintain the property upon a reasonable basis.

6. The industry can be restored to a normal basis only by the introduction of economies in operation, improving the tracks, equipment, and service, and assuring a reasonable return upon the fair value of its property used in the public service when honestly and efficiently managed.

7. The electric railways must expand to meet the growing needs of their communities; therefore, the first essential is to restore credit in order to obtain necessary new capital for the extension and improvement of service.

8. Restoration of credit involves a readjustment of relations which will remove public antagonism, provide public co-operation, and insure to the investor the integrity of his investment and a fair rate of return thereon.

9. Effective public co-operation should be exercised by eliminating, in so far as it is practicable, special assessments for sprinkling, paving, and for the construction and maintenance of bridges which are used by the public for highway purposes.

10. Extensions into new territory resulting in special benefits to the property in that vicinity should be paid for by assessments on such property in proportion to the benefits received, and the amount of such assessment should not be added to the physical value of the corporate property.

11. The great increase in the use of private automobiles, the jitney, and motor buses has introduced a serious, although not a fatal, competition to the electric railway. These forms of public motor conveyance when operated as public carriers should properly be subject to equivalent regulatory provisions.

12. The full co-operation of labor is essential to the highest prosperity and the usefulness of the industry. The employes engaged in this occupation should have a living wage and humane hours of labor and working conditions. They should have the right to deal collectively with their employers, through committees of representatives of their own selection. All labor disputes should be settled voluntarily or by arbitration, and the award of such a board should be final and binding upon both parties. It is intolerable that the transportation service of a city should be subject to occasional paralysis, whether by strikes or by lockouts.

13. A private industry should not be subsidized by public funds unless it is imperatively necessary for the preservation of an essential service, and then only as an emergency measure.

14. Unless the usefulness of the electric railways is to be sacrificed public control must be flexible enough to enable them to secure sufficient revenues to pay the entire cost of the service rendered, including the necessary cost of both capital and labor.

15. There can be no satisfactory solution of the electric railway problem which does not include the fair valuation of the property employed in the public service, and where that is done the companies should voluntarily reduce any excessive capitalization to the basis of such value.

16. There is no insuperable objection to a large, wide-open city having exclusive jurisdiction over the rates and services of public utilities.

17. The necessity for scientific and successful regulation of systems, whether large or small, and especially those which operate through several cities and villages and in rural territory, leads to the conclusion that local regulation should generally be subject to the superior authority of the state, whether as a matter of original jurisdiction or through the medium of appeal.

18. Cost-of-service contracts are in the experimental stage, but where tried they seem to have secured a fair return upon capital, established credit, and effected reasonably satisfactory public service. Such contracts may safely be entered into where the public right eventually to acquire the property is safeguarded.

19. The right of the public to own and operate public utilities should be recognized, and legal obstacles in the way of its exercise should be removed.

20. While eventually it might become expedient for the public to own and operate electric railways, there is nothing in the experience thus far obtained in this country that will justify the assertion that it will result in better or cheaper service than privately operated utilties could afford if properly regulated.

21. Public ownership and operation of local transportation systems, whether or not it be considered ultimately desirable, is now, because of constitutional and statutory prohibitions, financial and legal obstacles, the present degree of responsibility of our local governments, and the state of public opinion, practicable in so few instances, that private ownership and operation must as a general rule be continued for an extended period.

22. If the reforms incident to public regulation which we suggest in this report should not result in making private ownership satisfactory to the public, such reforms should at least enable public ownership to be established upon a just and equitable basis.

Statewide Optional City-Manager Bills Before Five Legislatures.—Bills to authorize the adoption of commission-manager government throughout the state by popular referendum are before the legislatures of Indiana, Illinois, New Jersey, South Carolina, and Wyoming. No cities in any of these states are now operating under commission-manager charters except in South Carolina, where three cities have secured charters. The new bill would obviate the difficulty of securing separate legislation in each case, and would tend to standardize the plan. In Illinois, several village suburbs of Chicago have created the position of manager by ordinance. The other three states are virgin territory. This is the first attempt to secure state-wide legislation in Wyoming and South Carolina, the second attempt in Indiana and Illinois, and the third effort in New Jersey.

Present Methods of Obtaining Railway Labor

The Committee on Economics of Railway Labor, of the American Railway Engineering Association, has recently completed an investigation on the above subject and has presented a report in a bulletin of the association, from which the following is taken, as being an indication of present practice, tendencies in certain directions, and some important changes recommended by the committee.

The questionnaire developed that very little is being done by the railways in the way of specializing for the selection of their maintenance of way labor. The returns when carefully analyzed also show that for maintenance of way labor, at least, the railways have not availed themselves of the lessons which the experiences resulting from the war merely developed and intensified, and that no positive action has been taken to overcome the economic conditions which tend to create serious labor shortages at different seasons of the year.

Excess Labor Recruited Through Labor Agencies.—Except for such labor as can be obtained locally, on approximately two-thirds of the roads throughout the country, the great army of excess workers required during the working season are, as a rule, recruited through labor agents, the majority of whom charge the men for securing the temporary job. There is no uniform practice as to the officer charged with responsibility for such matters; the tendency, however, seems to be to leave it, in a general way, under the engineer maintenance of way, where same exists. Where the services of these labor agents are utilized, it is almost the universal custom for the railways to obtain labor from various agencies, there being little tendency to accomplish this through a single source of supply.

As a general rule, railways do not pay bonuses or compensation to agencies for maintaining a stated supply of workers on their lines, but there are cases where this method has been followed, especially in times of labor stringency the agency being responsible for maintaining the supply and being paid accordingly. Very little, if any, written limitations or rules are placed upon labor agents concerning the manner and method that they shall observe in securing labor, although some states and the larger cities have regulations pertaining to same, which, however, are not very rigidly enforced.

Very few railways pay the agencies for securing their labor, it being customary for the labor agent to require the laborers to reimburse him for his efforts. This has resulted in a great many abuses which are alike prejudicial to the interests of the worker and the railways, and your committee has been impressed with the need of uniform regulations with respect to such matters.

During the war, the U. S. Employment Service was created, and for a time the indications pointed to some unified system, but for various reasons it ceased to be an effective factor as a labor gathering medium.

Many roads report that they use state and municipal agencies to a more or less extent but, as a rule, the majority of the roads rely on their own unorganized efforts, or a few utilize the services of free labor gathering agencies, either wholly or partially supported by themselves, but the majority depend upon the fee agencies, who, as previously stated, are supported by fees obtained from workers.

The majority of the roads do not contract maintenance work, although there is a tendency in this direction on some of the more important items requiring extra gangs, or where special skill is required.

Railway Maintained Labor Employment Offices.—Prior to the war, it was the practice for many roads to maintain labor agencies in the large labor centers, like Chicago, St. Louis, Kansas City, Omaha, etc. These were abolished during the war, but since the armistice was signed pre-war conditions have been restored and there has been a marked tendency to increase agencies either wholly or partially supported by individual roads entering the larger labor centers. There has also been a marked increase of fee agencies patronized by the railways.

No cases are reported where more than one road has combined for this purpose. There does not appear to be any uniformity of practice as to whom labor gathering agencies shall report, although the tendency is towards the maintenance of way department.

The reports indicate that in reality practically no limitation is placed on free transportation for transporting labor that cannot be obtained locally, and apparently no means has been found for protecting against the abuses resulting from the flagrant misuse of transportation furnished for the purpose of transporting this labor. In times of shortages, where labor cannot be supplied locally or obtained by labor contractors from territory tributary to the carriers, it is customary for most roads to pay fare for laborers recruited in off-line districts over other lines in order to bring them to their own road.

It is not the practice of the roads to invoke statutory requirements against the misuse of transportation, as no method has yet been found whereby this may be effectively used. This problem presents many difficult and baffling angles, and various remedies have been suggested, but they have failed by reason of an entire absence of co-ordinated effort among the roads.

No effective means have so far been developed to protect against the worker who, having accepted free transportation, fails to accept service. When such worker leaves the service after a few days' (or hours') service, as is frequently the case, few roads make any attempt to retain part of his earnings as partial compensation for such free transportation.

Length of Service of Casual Laborer.—The investigations of this committee, previously reported, have shown that the length of service for the casual worker is of exceedingly short duration, and the facility with which these transient workers may move from place to place is almost entirely responsible for this condition. The questionnaire, however, develops that the majority of the roads appear not to feel that the abolition of free transportation for these casual workers would operate to stabilize labor. The replies reaching the committee indicate a general recognition of this widespread abuse in connection with the transportation of laborers, but few practical suggestions have so far reached the committee for its remedy. The popular one seems to be that some arrangement should be worked out by each road whereby laborers will be piloted from the source of employment to the particular job for which they are engaged.

Where the services of boarding contractors are utilized to feed extra or floating labor, it is customary to afford free, reduced or limited transportation for their camp and food supplies, or approximately half of the roads reporting, the others assessing charges in some form or other thereon.

There is no accepted practice among roads concerning the wisdom of permitting their own employes to board extra or floating labor, when by doing so free or limited transportation for camp and food supplies are given.

The replies indicate a decided effort is being made to furnish houses for regular section foremen at nominal rental, and some feeble efforts are being made to furnish better quarters than heretofore for common labor, but it is not general.

The conditions in the Eastern section do not, as a rule, require this for its excess labor, whereas in the West it is necessary in some form on account of the long stretches of open country and the comparatively long distances between the towns. The majority of the roads furnish bunk houses for their laborers for which no rental is charged, but as a rule they consist of old car bodies. Some tendency for improvement in this direction is reported.

It is the general practice for the railways to supply housing with wood or steel bunks for their floating, or semi-permanent labor, but the bedding, kitchen and other utensils are supplied by the boarding contractors, or the laborers themselves.

It is also the general practice to supply cooks for track gangs, but no uniformity exists as to the number in proportion to the men employed. This applies to bridge and building department and miscellaneous employes as well.

The majority of the roads reporting apparently contract with companies or individuals for feeding their common labor that is seasonably employed, the balance evidently believing that better results are secured where this is not done.

There is almost an entire absence of trained supervision over food, sanitation or camp supplies for the workers. Where such supervision exists it is usually of a sporadic character and confined to local officers engaged in other duties. One large Eastern road, however, has assigned the feeding of its laborers to its dining car department and through it secures the benefit of the same sanitation and supervision of its food and camp equipment th[illegible] [illegible] tions.

There is a marked difference [illegible] of Eastern and Western roads in the matter of engaging and caring for labor. The general tendency of the Eastern lines is to so arrange their maintenance work that it shall be done with regular force and [illegible] as possible, the use of extra gangs, whereas, as a general rule, the Western roads depend on the extra gangs and casual labor to supplement the work of the sections, principally for relaying rail, ballasting and similar heavy work.

Stabilizing Labor.—There appears to be an almost universal appreciation by the roads of the serious effect that intermittent labor has on their organization and efficiency in maintaining the railways of the country. There is also a general feeling on the part of a majority of the roads that this can only be corrected, or at least minimized, by working out a more scientific method of arranging the maintenance of way program whereby large armies of workers will not be made idle during a very considerable part of the year. The annual man-hours remain about the same, but due to the fact that it is not scientifically arranged, a great many excess workers remain frequently on furlough, creating an economic condition that is hurtful to all concerned.

There is a universal feeling that before very much can be done by railways to stabilize labor, housing and living conditions must be more in conformity with the current practice of industrial and similar concerns, who seem very dium that will react powerfully to stabilize railway track labor. A better distribution of the forces so arranged as to give consideration to the comfort of the foremen and their families are a greater asset than is popularly supposed for increasing the efficiency, contentment and loyalty of the worker.

New Gasoline Shovel

A new design of power shovel built for gasoline operation has been brought out by the Austin Machinery Corporation, Chicago, Ill. The shovel has patented air controlled clutches enabling the operator to manipulate the principal operations with ease. Cushion-drive clutches of swinging and crowding devices satisfactorily insure the necessary overlapping of operations. All operations may be quickly reversed at any time. The swinging machinery and hoisting drum are locked by means of automatic brakes when the power is shut off. Other features of the shovel include: Three-lever digging control; "slam the dipper" door (a clean dipper); power boom hoist; quick replacement of clutch bands; interchangeable clutch parts; complete accessibility.

Austin Gasoline Shovel, Model 6-T.

A New Explosive that Cannot Freeze.—A non-freezing explosive has been placed on the market by the Atlas Powder Co., Philadelphia, Pa. Some of the claims made for the explosive are: (1) Five grades for every blasting requirement; (2) Cannot freeze at any temperature; (3) Withstands the heat of summer; (4) Its stability avoids premature explosions (nothing weaker than a No. 6 blasting cap should be used to detonate it); (5) Will not cause headaches to those who use and handle it; (6) Made in all standard size cart-

Economy in Railway Water Treatment

Some recent figures on the advantages obtained by investment in water softening plants are given in the Railway Age by Mr. Paul M. La Bach, Engineer of Water Service, C., R. I. & P. Ry., Chicago. The Rock Island is one of the largest western railway systems and traverses regions where much of the water obtainable is classed as hard, thus making it desirable to treat it for locomotive use. While water softening has been resorted to for some years at many points, Mr. La Bach states that the present policy of the road is to fill in the "blank" points and thus secure engine districts on which all water requiring it will be treated. The following data is abstracted from Mr. La Bach's article:

The Rock Island has a total of 412 water stations or an average of one about every 20 miles. At 25 per cent of the stations the water is bought from municipalities.

The balance is handled by company forces. About 50 per cent of the water comes from open or tubular wells, 25 per cent from streams, 10 per cent from impounding reservoirs and the balance from lakes, springs, etc. From these various sources over eight billion gallons are pumped by company forces per year and over one billion gallons are purchased from others. The methods of pumping the water are as varied as the sources of supply. Steam, internal combustion engines, electricity and gravity stations are found.

A tabulation of the analyses from all the 412 water stations shows that 290 stations furnish water of over 10 grains hardness per gallon. Of the 117 stations which take water from streams, all may be said to carry large quantities of silt part of the year and a number practically all of the year. As mud is readily removed in a water softener, the muddy water territories with hard water are being handled with reference to both the suspended and dissolved solids.

Computations based on the A. R. E. A. formula of 10 ct. saved through the removal of each pound of incrusting solids give the total of $358,552 saved per year, not including interest, repairs or depreciation of plant. The total cost of plants was $305,587. This gives a gross operating saving of 117 per cent. If the interest on the cost of plant is 6 per cent this will be reduced to 111 per cent. Depreciation and repairs will subtract another 8 per cent and thus leave the net profit at 103 per cent on invested capital. In this computation no credit has been taken for mud removed, although a large quantity has been taken out at many of these points. The saving due to the elimination of mud must be estimated in each particular case. No formula of general applicability has been devised.

In this accomplishment two elements have entered into the result, namely, supervision and design. The two operating districts of the Rock Island each have a supervisor of chemical tests and a supervisor of water stations, in addition to the division forces, whose duties require them to follow the daily operations of each station. By the follow-up methods installed, satisfactory treatment is secured with all the different types of plants when operated properly. When in good working order the question of operating capacity is the principal element of difficulty. The capacity varies even with apparatus of the same design and any crowding or hurrying the process produces much harm. The "intermittent" and "soda ash" apparatus is home made. With a few exceptions the tubs are wooden. The "continuous type" machines are of the general type made by the patentees at the time of installation, with such variations as were thought to best suit local conditions.

Advocates of Engineer License Laws Busy in Many States.—The engineer's license law introduced into the Indiana legislature at the instance of the chapters of the American Association of Engineers in Indiana was reported favorably by a house committee on Jan. 28. The chapters of the association in Texas were successful in supporting their engineer's license bill at a committee hearing held at Austin on Feb. 2. The Atlanta, Ga., Chapter has its license law almost ready to introduce. A New Jersey engineers' license bill, providing for the licensing of professional engineers and land surveyors, was introduced on Feb. 7 in the New Jersey legislature as a result of joint action of the Trenton and New York Chapters of the American Association of Engineers.

The Duties of a Roadmaster*

By R. E. KEOUGH.

Assistant Engineer, Maintenance of Way, Canadian P[illegible]

While the roadmaster is supposed to be purely a maintenance man, he is such only where roadbed is old and well-ballasted. After construction the track is turned over to the maintenance of way department with the expectation that construction days are over. This is usually erroneous, as it is generally found that construction as practiced on this continent is only well commenced when the maintenance of way department takes charge. Sufficient attention is not given to proper drainage to cuts or crowning and settling of fills. The present practice of hurried construction work calls mostly for machine work, such as train filling from steam shovels, or heavy blasting, all of which tend to lower the cost of construction.

Soundings may be made to determine the depth of muskegs, but aside from this no such accuracy is used in building roadbed as is followed in bridge construction.

The construction engineer merely hopes to see the earth's crust stand up under the heavy wheel loads. Although it does this to everyone's satisfaction in the majority of cases, there are, however, numerous instances where the roadbed is found to be anything but desirable. These are places which cause much worry to the roadmaster and maintenance engineer. If they are ever entirely cured it is only after long years of constant work. Ideal construction would mean that such places would be broken down and the bottom found, when the grading was being done, rather than allowing it to do so gradually under several years of operation and maintenance.

Oftentimes cuts are taken out of fills made which are scarcely passable even for light construction equipment, which will in no degree cope with the heavy traffic which is to follow.

Lines have frequently been built and ballasted, but inspected while "frozen in," and pronounced satisfactory when afterward the same road is found impassable. I merely mention this to show how poor construction is reflected to maintenance. The roadmaster is often whipped over the back for rough track made by such conditions as these and where money is available he must see to it that these early day defects are corrected, either gradually or otherwise.

Although improper construction shows up in any part of the country it is perhaps more pronounced in the northern portion, where frost enters deeply into the roadbed, causing excessive heaving, or in the gulf states, where rainfall is heavy during the winter months.

This is one of the hardest jobs a roadmaster has to combat. Heaving spots must be carefully marked so as to have them "dug out" during the summer months.

Much care is needed when digging in order to avoid going too deeply, which will cause a hole that will ride as badly as the high spot did before.

It is usually found that roadbeds contain enough moisture in a climate similar to this to cause heaving by frost to a certain degree. It is only the irregularity of heaving that gives us trouble. This is often noticed where we originally had open pit cattleguards, which were later filled up with clean ballast or cinders, which do not permit the track above it to heave correspondingly to the track approaching it. The result is we have shimmed track at such points, even on our oldest lines.

When making inspection with a roadmaster some time ago he called my attention to two cattle guards which he had treated while foreman of that section several years before. He had, with two men, in one day, dug out all the ballast from two old pit guards and had back filled them with clay up even with the clay found in the adjoining roadbed. He then applied a similar depth of ballast to the track, either side.

The result is entirely satisfactory, as it is found that these places have never given trouble since.

There are still many such places which can be corrected on our roads equally as easily by observing trackmen who are given the money and labor to do the work.

In the most northern states metal cattleguards are sometimes used as well as wooden ones, both of which are left in over winter. The roadmaster soon notices the track does not stay as low under metal guards as it does with the wooden ones, owing to the steel guard permitting frost to enter easily, allowing track to heave a corresponding amount under them.

Also he will find he often can save considerable shimming and rough riding track by putting a temporary door over culverts which are close to the surface, and where it is found the frost goes up from the culverts as well as down from the top of ballast, causing double heaving.

The curving of rails is a live subject and one which has been handled with perhaps less regularity than is generally supposed by most of those not immediately connected with the work.

We frequently notice angular looking joints on the inner side of curves and on inquiry learn that this is due to the fact that these rails were not curved when laid. Close scrutiny will prove that the rail very likely was laid with excessive expansion on this curve and that the joint bolts were badly neglected at one time or another. These two factors taken together allow rail ends to tend to straighten out and appear kinky. It is found that even at the sharpest curves curving need not be done throughout the full length of a rail, nor will they show signs of joint kinking if a slight set is given each rail close to each end with a Jim Crow. This will care for even neglected bolts or excessive expansion, as well as if curved throughout the entire length of the rail.

You will not see kinky looking switches on the more observing roadmasters' territory. In fact, under normal conditions a switch should be the last to go out of line, as there are at this point four rails instead of two as well as heavy timber, which make for better conditions. Such defects are the result of improper attention given to expansion on rail approaching the switch or hunching of rail at this point, which has been neglected through ignorance or shortage of labor.

The roadmaster who studies his conditions will know that frogs of all kinds, when used on high-speed tracks, will last and ride better where gage is kept snug. This is more important when frogs are located on inner rail of curves. With good close gage the wheel flanges are directed through the flange-way provided for them instead of being allowed to pound the frog to pieces by striking the wing rails sharp blows while passing.

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*From a paper presented last fall before the Canadian Railway Club, Montreal, Que.

Rental Schedule for Construction Equipment.—A rental schedule for construction equipment, prepared by a committee of the Associated General Contractors of America, was printed in our Dec. 15 issue. In the report of the committee submitted at the annual meeting of the association last month another column has been added to the table shown on page 583 of the above issue. This column covers the "equivalent annual interest at 6½ per cent." It increases the total annual charge per cent of initial investment (the last column in the table) by 4 per cent. It should be noted, however, that contractors should determine the proper interest charge for each job after determining the prevailing rate in accord with one of the three ways suggested in the article.

New Jersey Road Material Exhibit and Convention.—The New Jersey State Highway Department will hold a road material exhibit and convention at the Grand Theater Bldg., Trenton, N. J., Feb. 23-26. The exhibit is to be used in connection with a series of lectures which will be delivered by different highway officials of New Jersey and other states. In order that the materialmen may become better acquainted with the different grades of materials which have been approved for use in highway construction, the method to follow in using these materials and the general personnel and work of the Department, they have been invited to attend the convention.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

J. J. McInerney showed up here the other day. Mack is grading real estate at Akron, O.

The Massman Construction Co. are finishing their riprap and shore protection work on the Missouri River.

Tom Walsh of the Walsh Construction Co. passed through here on his way to Arkansas City, Ark., where they are operating a gravel pit.

[illegible] & [illegible] completed their [illegible] and went [illegible] St. Louis [illegible] after them.

The P. J. [illegible] Co. [illegible] have [illegible] grade team [illegible] place [illegible] immediately.

[illegible] was [illegible] by the [illegible] St. Louis City Council to [illegible] by the [illegible] of F. A. Cooper.

Sparks Atkinson Construction Co. writes from Fordyce, Ark., that [illegible] the market for a [illegible] job in this [illegible]. Can place an outfit of [illegible].

[illegible] C. Clarr was in from [illegible] getting [illegible] prices on some wheelers and a grader. Clarr expects to get some of the new state road work to be let at Springfield, Ill., this month.

Wm. Kenefick, one of the oldest railroad contractors in this part of the country, died at Garden City, N. Y., Jan. [illegible]. At the time of his death he was spending the winter with his daughter, Mrs. Arthur Day.

The State Public Service Commission on Jan. 26 granted the electric light company of Excelsior Springs authority to build an extension line to Liberty for the transmission of electric current for [illegible] purposes.

C. P. O'Reilly & Co., 624 Wainwright Bldg., St. Louis, Mo., have two pieces of road work to sublet. One of these jobs consists of [illegible] yd. of machine work at Hopewell, Mo., and one of [illegible] yd. of wheeler work at Frankfort, Mo.

Wm. Condon, of Condon & Bolen, was a visitor at Koenig's new office in Kansas City. Has been resting up at Hot Springs for several weeks. Returning to Omaha to start track laying for the street car company there.

John W. Ground, railroad builder and mine operator, died at his home in Kansas City, Jan. 26, following a short illness. Ground was vice president of the Joplin-Pittsburgh Railway Co. and an extensive holder in zinc and lead mines in Missouri and Oklahoma. He was [illegible] years old and a native of Indiana.

On Feb. 1 Koenig's Labor Agency in Kansas City was removed from 503 to 501 Delaware St., corner of Fifth. There is a special room reserved for contractors where visitors can clean up, write letters, sharpen pencils and get posted on what is going on out west. Newt. Paisley is manager of this office.

A contract for the labor in constructing three miles of concrete road between Belleville and Mascoutah, Ill., was awarded Jan. 29 by the Board of Supervisors at Belleville to Koeffken Bros. for $62,000. The county will furnish the materials. The cost of the work is estimated at $125,400. The road between the two cities is [illegible] in length.

Officials of the American Locomotive Co. of Pittsburgh filed deeds to the purchase of 166 acres of land in Venice Township, Madison County, Illinois, upon which will be erected a $25,000,000 locomotive plant. A price of $1,367 an acre was paid. The land was purchased from trustees representing fifteen separate interests. This is an addition to the tract of 205 acres recently acquired by the company.

Eugene S. Beaty, aged 60, for many years Washington county bridge contractor, died at his home in Blair, Nebr., after an illness of several weeks. He leaves a widow, one son and one daughter.

Ben Reynolds, who has been in charge of the P. J. Hannan Co. work at Jonesburg, Mo., has finished this job. Is going to spend the balance of the winter with his son, John Reynolds, at Huntsville, Tex.

The Board of Aldermen of St. Louis without a dissenting vote on Jan. 28 passed a measure to repeal the municipal contract ordinance, commonly known as "board bill 28," which regulated the letting of contracts for public work, containing special provisions as to the kind of labor to be employed and the wages to be paid. The repeal of the law means the definite end of a bitter fight between the local contractors and labor organizations, which lasted more than a year. "Board bill 28" was passed by the Board of Aldermen about a year and a half ago, following a number of public hearings at which stormy protests against the proposed law were made by local contractors and financiers. The contractors claimed that the ordinance would invalidate the city's special tax bills, inasmuch as it ordered the contractor to pay his men a certain amount of wages. They also contended that the banks had refused to lend money on the special tax bills as long as the ordinance was in existence. Following the passage of the law the contractors informed the Board of Public Service that they would refuse to bid on public work and that the city would either have to do its work itself or else repeal the contract ordinance. The threat was carried out by the contractors, and when no bids were received at several lettings of the Board of Public Service it was finally decided by President Kinney of the board to appeal to the Board of Aldermen in behalf of a repeal of the measure. Since then aldermen have delayed action on the repeal for many weeks until the bill came up for repeal. Before a vote was taken a letter was read, written by Secretary Maurice Cassidy of the Building Trades Council, explaining the attitude of organized labor with regard to the bill and pleading with the Board of Aldermen for a still further delay in the matter of repealing the law.

Personals

Alexander England has been appointed Chief Engineer of the Westinghouse Air Brake Co., to succeed S. W. Dudley, who resigned Feb. 1st to join the faculty of Yale University as a professor of Mechanical Engineering.

Major Clyde V. Taylor has resigned from the U. S. Indian Irrigation Service after 6 years' service with that department, and has joined L. H. Taylor, Consulting Engineer, in private engineering practice at Reno, Nevada, under the firm name of L. H. Taylor

R. N. Kinnaird has opened an office at 204 Iowa Bldg., Des Moines, Ia., where he will engage in a consulting practice, specializing in Water Supply and Purification, Municipal Sanitation, Sewerage, Power Plant Engineering, Coal Mining, Coal, Sand and Gravel preparation and handling.

[illegible] Taylor, Assistant Chief Engineer of the McClintic-[illegible] Pittsburgh, Pa., has been appointed Chief Engineer of that company, succeeding the late Paul L. Wolfel. Mr. [illegible], who held the position of Assistant Chief Engineer for the [illegible] twelve years, graduated from the University of Pennsylvania [illegible] connection with the McClintic-Marshall Company dates from a period shortly after the inception of that company, and his experience includes a prominent part in the construction of most of the great bridges and other structures erected by the company.

Walter F. Shaw has been elected president of the Jamestown Engineering Society, recently organized by engineers and architects at Jamestown, N. Y. Other officers are: Vice President, E. C. Dollard, City Engineer of Jamestown; Secretary, H. G. Garlock, Chief, Contract Department, Dahlstrom Metallic Door Co.; Treasurer, F. A. Irvine, former City Engineer. The executive committee consists of the following: E. W. Sellstrom, Superintendent, Dahlstrom Metallic Door Co., chairman; L. L. Graham, of Chapman & Graham; T. A. Hulbert, Managing Editor, "Good Roads"; Wm. J. Knauer, County Superintendent of Highways of Chautauqua County; and C. O. Hultgren, Superintendent of Streets, Jamestown. The present membership of the society is about forty, but it is expected that there will be twice that number within a few weeks. Meetings are held twice a month, on the first and third Wednesdays.

Michael Idvorsky Pupin, professor of electro mechanics at Columbia University and a past chairman of Engineering Foundation, established to further research in science and in engineering, will be awarded the Edison Medal for his work in electrical engineering. The Edison Medal is awarded annually to a scientist who has done notable work in electrical engineering. Dr. Pupin, one of the foremost figures in American scientific research, receives the honor for his work in the improvement of telephone communication by means of loading coils and for his recent work in connection with high frequency electric currents. Prof. Pupin was born in Idvor, Banat, Hungary, Oct. 4, 1858. He was graduated from Columbia College in 1883 and in 1889 received the degree of Ph. D. from the University of Berlin. Prof. Pupin recently stated that when he came to America as an immigrant youth his material wealth consisted of an apple and five cents in cash.

Obituaries

Ernest S. Draper, principal assistant engineer of the Boston & Albany R. R., died Feb. 6. He was born at Weyland, Mass., on Feb. 19, 1883. After attending the public schools at Weyland he entered Tufts College at Medford, Mass., and graduated with the class of 1904. In January, 1905, he entered the employ of the Boston & Albany R. R. as rodman and left that company in March, 1912, to accept a position as draftsman with the Stone & Webster Engineering Corporation at Boston. In April, 1913, he re-entered the employ of the Boston & Albany as assistant engineer, was appointed engineer of structures in January, 1918, and in May, 1920, principal assistant engineer. He is survived by his widow and two children.

Frank P. McCaughey, one of the pioneer railroad contractors of the Middle West, died suddenly Feb. 4 at his late residence, No. 1319 Columbia Ave., Chicago. Mr. McCaughey was a member of the firm of McCaughey Bros., which he and his two brothers, John J. and Patrick E., formed in 1882. In 1892, Mr. McCaughey married Elizabeth Cullen, who, with two sons, John Alva and Russell Jay, survive him. He also leaves to mourn his loss, two brothers, John J. and Patrick E. McCaughey, and three sisters, Mrs. McGowan, Mrs. Kennedy of Aurora, Ill., and Mrs. Hunter of Philadelphia. Mr. McCaughey was a member of the Holy Name Society of St. Ignatius Church, and of the University Council, K. of C., and had resided in Chicago for the past 30 years. Requiem high mass was celebrated at St. Ignatius Church Wednesday morning, February 9th; interment at Calvary cemetery.

Frederick William Shepperd, founder and for 33 years proprietor of Fire and Water Engineering, died Feb. 8 at his home, 1006 East 31st St., Brooklyn, N. Y. He had been failing in health for two years, which prompted his withdrawal from Fire and Water Engineering. With him passes a most conspicuous figure at both fire department and water works conventions. For a period of over 30 years hardly a single convention passed at which he was not present. Mr. Shepperd was a pioneer in the trade journalism field. His early publication training was received, first, with a Toronto, Ont., newspaper, following which he entered the trade journal field as one of the first employes of Engineering News, now known as Engineering News-Record. Leaving the Engineering News in 1886, Mr. Shepperd joined the forces of the Firemen's Journal, then a struggling little weekly of a dozen pages. It took him but seven months to put the paper on its feet, and so promising did the field ahead appear to him that he arranged to secure control of the journal. This he attained in November of 1886, and the scope of the paper was broadened to cover fire protection and its allied field, water supply, the name being changed to Fire and Water. Other results of his labor may be found in Handbook of Water Works and Fire Department Statistics; Fire Service Review, a monthly fire department publication, which appeared for a decade and which was discontinued on the rapid growth of Fire and Water Engineering. Contract News, an engineering and contracting paper, was also founded by him and was later taken over by Engineering and Contracting of Chicago.

Industrial Notes

The Jeffrey Manufacturing Co., Columbus, O., has removed its Denver, Colo., office from the First National Bank Bldg. to 421 United States National Bank Bldg.

The Associated Manufacturers of Water Purification Equipment held their annual meeting in Chicago on Feb. 2 with an attendance of a large majority of the membership. Many matters of interest were discussed, especially the question of standardization, and considerable progress along this line made. Also some papers of interest to the manufacturers were read and discussed. The officers for the ensuing year elected were: M. F. Newman of the W. B. Scaife Co., president; G. F. Hodkinson of the American Water Softener Co., vice-president, and H. G. Tate was re-elected secretary for the ensuing year.

At the annual election of officers of the Concrete Mixer Association of the United States recently held in Chicago, Clifford F. Messinger, General Sales Manager of Chain Belt Co., Milwaukee, was elected president; W. B. Knickerbocker of the Knickerbocker Co., Jackson, Mich., was elected vice-president; A. T. Scannell of the Archer Iron Works, Chicago, Ill., was elected treasurer; H. E. Smith, president of the T. L. Smith Co., Milwaukee, Wis., was made chairman of the executive committee, while P. A. Koehring, secretary of the Koehring Machine Co., Milwaukee, Wis., and Z. W. Carter, sales director of the Austin Machinery Corporation, Chicago, Ill., were elected members of the same committee. The installation of officers took place at a dinner given by the association at the Atlantic Hotel, Chicago, on Friday evening, Jan. 28.

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Index of E. & C. Now Ready

The index for Vol. LIV covering the July-December issues of Engineering and Contracting is now ready for distribution. Subscribers desiring a copy should notify us at once. Those who received the indexes for the previous volumes have been listed and need not notify us again.

A Scientist Writes on Unscientific History

H. G. Wells, author of 28 novels and 12 books on social topics, has recently written a two-volume "Outline of History" that has received many favorable reviews. It is perhaps the first history whose author has had much training in physical science. For that reason alone it merits the attention of engineers. But we must caution our readers against expecting a truly scientific treatment of history at the hands of Mr. Wells. Although his early training was in science, most of his life has been spent in imaginative writing, and the effect of this later training is not conducive to a philosophical analysis of social events, however much it may have enhanced his power of vivid portrayal.

Wells essays to produce a "Plain History of Life and Mankind," beginning with Gilbert and Sullivan's "protoplasmic globule" and ending with the "Catastrophe of 1914." As a matter of fact, the book is almost as much an essay on socialism as it is a history. While most of its pages are a recital of facts or alleged facts, there runs through all the thought that mankind has been evolving from individualism to collectivism, and the culmination thereof is to be socialism. To those who have read the works of a much more scientific writer, Herbert Spencer, it will be apparent that Wells has repeatedly strained the facts to fit his theory. Spencer interprets social evolution as being away from collectivism toward individualism, away from social restraint toward individual freedom. Probably there is truth in both views. In other words, there has been a progressive increase in individual freedom in many respects, accompanied by progressive restraint in other respects. Egoism and altruism are not incompatible traits of human nature, although they do pull in opposite directions. Gravitation and the motive power of a bird's wings act in contrary directions, but both are essential to successful flight. There we see physical opposition, but not incompatibility. Why may not mental forces similarly be opposed, yet capable of resulting in a moving equilibrium? Are not such extremists as Wells unscientific when they see nothing but evil in one of two opposing mental forces, and nothing but good in the other?

Wells' lapses from the scientific method of interpreting phenomena are very frequent, and especially noticeable when he undertakes to predict the future. Listen to this sentence:

> On the night of Aug. 2 (1914), while most of Europe, still under the tranquil inertias of half a century of peace, still in the habitual enjoyment of such a mildly diffused plenty and cheapness and freedom as no man living will ever see again, was thinking about its summer holidays, the little Belgian village of Visé was ablaze, and stupified rustics were being led out and shot because it was alleged someone had fired on the invaders.

Now, a careful scientific writer would never have said "as no living man will ever see again," for many a living man will live another 70 years, and 70 years, as Wells had previously shown, has resulted in marvelous industrial progress. But if this was merely a slip, such as an author of exuberant imagination is apt to make, what of this?

> It was becoming very evident that unless there was to be some profound change in the spirit of business under an unrestrained private system there was little or no hope, in Europe at any rate, of decent housing, clothing, or education for the workers for two or three generations. These are facts that the historian of mankind is obliged to note with as little comment as possible. Private enterprise in Europe in 1919 displayed neither will nor capacity for meeting the crying needs of the time.

Note how Wells charges against "private enterprise" the temporary industrial debacle in Europe following the close of the war, where it is at least probable that "public enterprise" was more to blame than "private enterprise." In another place he mentions the tremendous effect of the issuance of paper money and the complete d [illegible] consequent upon that inflation. That fact alone suffices to account for the general upset of business in Europe, and it is certainly not ascribable to "private enterprise." With equal disregard of the blighting effect of stupendous income taxes, and the demand of British labor unions for the nationalization of the great industries, Wells lays the entire blame for business depression upon the selfishness of capitalists. This is indeed scientific history, if it be scientific to ignore all the industrial conditions save one and attribute to that one the cause of every ill!

Wells speaks of the rapid increase in general prosperity in Germany during the 50 years prior to the war and attributes it to the unprecedented spread of scientific education and research. He fails to comment upon the even greater increase in prosperity in America during the same period, although he was doubtless aware of it. But these are facts that do not fit his theory of "progress and poverty." Like his illustrious prototype, Henry George, he sees clearly only such facts as lend credence to his philosophy. He attributes Germany's progress to scientific education, and Britain's relative stagnation to lack of such education. There is doubtless some truth in this analysis, but may there not be a fuller explanation in other differences between the two countries. For example, British labor unions had been growing steadily more powerful in Britain, and had been coincidentally reducing the output of workmen, both directly and indirectly. In the structural trades, where little or no competition with other countries exists, the British workmen had not only put an end to progress, but had declined grossly in output. British quarry owners, for example, were not allowed to introduce American quarry machinery, such as rock channellers. Similarly British coal miners had prevented the introduction of American coal cutting machines, and the like. But of all this Wells says not a word, apparently because it does not fit his theory that "private enterprise" is the cause of British industrial stagnation. Truly it is a curious thing, this "private enterprise," that was making America and Germany great industrially and giving prosperity to all ranks, yet was throttling progress in the British Isles.

Wells is not only insular as to nationality, but as to his knowledge, nor have his intellectual excursions carried him far enough afield, even in the writing of his Outline of History, to free him from that insularity. Yet his Outline will appeal to most educated men because it is charmingly written and delightfully simple in its explanation. There is seldom more than one force in any of the "complexes" that Wells analyzes. Even as he finds nothing save vanity and ruthlessness in Napoleon's genius, so he finds "private enterprise" to be little else than a myriad of minor Napoleons.

The Law of Supply and Demand Never "Ceases to Operate"

Nowadays we frequently read such statements as this: "The law of supply and demand is beginning to reassert itself" and "The law of supply and demand ceased to operate during the war." Even scientific writers are not always free from the error of speaking of a natural law as if it were a human law.

A natural or scientific law states an unvarying relationship between such and such things. It never "ceases to operate." John Stuart Mill in his "Logic" repeatedly confounds natural laws with natural forces, using the term law as if it were a synonym for force. He also commits the common blunder of speaking of natural laws as if they were institutions subject to a changing will.

A natural law may not apply under certain conditions because the forces named or implied in the law are not all enacting in the manner prescribed by the law. But this is quite different from saying that the law has "ceased to operate." It is merely equivalent to saying that the law does not apply. A natural law is "universally applicable" only when the conditions of its applicability are present. The universality of the law merely refers to the absence of any exceptions to it, and not to an incessant manifestation of it. It is universally true, for example, that a balloon filled with a gas lighter than air will rise, but this is not equivalent to saying that gas filled balloons are incessantly rising.

Of another sort are the errors of those that tell us that prices have risen during the past few years because the law of supply and demand was inoperative. As a matter of fact, prices rose in exact accordance with that law, because the effective demand, measured in money, increased faster than the available supply of goods. The total effective demand during a year is measured by the total currency in circulation multiplied by the velocity of circulation (i. e., $M \times V$). The available annual supply of commodities is the product of the number of people by their per capita output (i. e., $P \times E$). The ratio of demand to supply, $(M \times V) \div (P \times E)$, determines the average price or price level. This is a condensed statement of the law of supply and demand as applied to price levels. It makes clear the error of attributing high prices to cessation of the law of supply and demand.

Estimating Fair Rentals

Recently laws and ordinances have been passed to control rents on houses and tenements. This may ultimately lead to public regulation of rentals on all urban real estate. But whether it does or not, there will be more scientific study given to the estimating of fair rentals.

William C. Bentert, former president of the Philadelphia Real Estate Board, gives the following estimate of the annual cost of operating dwelling properties:

	Per cent
Repairs	1.0
Depreciation	2.0
Insurance	0.1
Management	0.5
Vacancies	1.0
Taxes and water rates	2.5
Total	7.1

The U. S. Housing Corporation estimates the corresponding costs as follows:

	Per cent
Repairs	1.4
Depreciation	3.0
Insurance	0.2
Management	0.5
Service	0.5
Vacancies and bad debts	0.7
Taxes and assessments.	1.4
Total	7.7

There will doubtless arise considerable difference of opinion as to the allowance for depreciation, particularly where a city is growing at such a rate as to cause a marked appreciation in the value of land. Will not appreciation of land offset in large measure depreciation of buildings?

A writer in a building magazine infers from the above given data that not less than 13 per cent of the total value of residence property should be taken as a fair rental basis, that is 7 per cent for operating expenses and 6 per cent for interest. This is clearly erroneous, for the 2 to 3 per cent for depreciation and the 1 to 1.4 per cent for repairs apply only to the building and not to the land. Moreover, the depreciation percentage should apply to the original cost of the house, whereas the repair percentage should apply to the present cost of reproducing the house.

Considering the enormous investment in buildings, it is really surprising how meager are the published data relative to the costs of operation.

Convention of New Organization of College Student Engineers.—Choosing the Missouri School of Mines at Rolla as their next meeting place, college student engineers from the middle western engineering colleges closed their second annual convention Feb. 12 at Iowa State College, Ames, after changing the name of their organization from "Guard of St. Patrick" to "Association of Collegiate Engineers." William Crilly, a senior mechanical engineer at Iowa State, was chosen president of the new organization. The vice-president is to be chosen from the senior student body of the Missouri School of Mines. The purpose of the "Association of Collegiate Engineers" as stated in the constitution, is to promote interest in engineering work between students of the different institutions, to foster engineering student government and to standardize engineering college publications. It is an outgrowth of the recent "Order of the Guard of St. Patrick," a local engineering society having chapters at several mid-western engineering colleges. Delegates attended from Missouri, Iowa, Colorado, Tennessee, Arkansas, Oklahoma, Oklahoma A. & M., Missouri School of Mines and Iowa State. Fifteen schools are ready to take charters in the new organization.

Book Reviews

Concrete Houses—How They Were Built. Edited by [illegible] Whipple, Editor of Concrete. 215 pp. 9 by 12 in. Cement Age Publishing Co., Detroit. 1920.

The title page announces that the book is "compiled from Concrete in response to a demand greater than could be met with copies of house building numbers of that magazine."

Here is an excellent compilation of much that the prospective home builder will want to know; in addition to which it is not without value to the architect and the contractor. Frankly an argument in behalf of concrete—its claims are urged in gentlemanly fashion and without subterfuge. The preface makes plain that only good concrete is recommended.

The first section, entitled "Concrete Houses," deals with the aesthetic and miscellaneous advantages of concrete. It points out forcibly that concrete design should not attempt deception by masquerading as stone, brick or frame. "When concrete is used, the designer should think in terms of concrete, from footing to parapet."

"How Will the Builder Get a Concrete House?" is the title of the second section, in which are presented the economic advantages of concrete.

Following this comes a set of half-tones really convincing of the artistic adaptability of concrete. It includes general views and details of homes in widely separated parts of the country, and also a set of eight "close-ups" of finished surfaces of various types as follows: Blocks in two grades of facing mix; fine tooled surface of moulded concrete; brushed and acid-washed surface of mica spar crystals; white stucco: dry dash stucco with colored aggregates; coarse tooled surface; brushed-out surfaces of various mixtures.

The fourth section constitutes by far the largest part of the book and consists of a series of articles giving many plans, details, views of finished and unfinished work, description of methods, and collections of cost data on single house and group construction.

Succeeding headings to brief articles are "What Shall Be Done About the Surface"? "Burned Clay Inserts," "Mosaic Enrichment," and "History and Development of Stucco."

Standard practice for portland concrete stucco as recommended by the American Concrete Institute is given in full.

The final section is a collection of articles by seven men and women reciting their actual experiences in living in concrete houses.

Concrete Work, Volume I—A Book to Aid the Self-Development of Workers in Concrete and for Students in Engineering.—By William Kendrick Hatt, Professor of Civil Engineering, Purdue University, and Walter C. Voss, Head of Department of Architectural Construction, Wentworth Institute. 451 pp., 241 figures and plates. John Wiley & Sons, New York, 1921. $4.00 net.

This volume is the first of a series of industrial texts edited by W. H. Timbie, Associate Professor of Electric Engineering, Massachusetts Institute of Technology, from the material and experience of the Committee on Education and Special Training of the War Department, under whose direction was conducted the successful training of 130,000 soldiers in various vocations and trades in 147 different schools during the war period. The authors were both intimately connected with this work, Professor Hatt having planned and supervised the army training in concrete construction, while Mr. Voss had immediate charge throughout the war of the training given in this subject at the Wentworth Institute.

The primary purpose of the work is clearly set forth as follows: "The purpose of these volumes is to extend the scope of work now possible to the concrete worker of unguided experience by bringing him to an intelligent understanding of the scientific principles underlying his art and by introducing him to the wider opportunities that exist for him in modern concrete construction;" and in this purpose it is believed that the authors have been successful. For such a book there is a very evident place, but its field of usefulness is by no means limited to that place alone.

Chapter headings are as follows: "I. Opportunities in the Concrete Industry. II. Plans, Details and Specifications. III. Simple Footings. IV. Column Footings. V. Concrete Walls. VI. Reinforced Concrete Frame. VII. Erection of Reinforced Concrete. VIII. Pre-cast Stone. IX. Walls and Partitions. X. Concrete Walks and Paving. XI. Building Finish. XII. Special Concrete Construction. XIII. Estimating.

Appendixes covering 90 pages are as follows: A—Aggregates. B—Manufacture of Cement, C—Standard Specifications and Tests for Portland Cement, D—Suggestive Specifications for Concrete Storage Tanks and Reservoirs. B—Typical Waterproof Construction, F—Estimating Concrete Buildings. G—Data for Estimating.

The table of contents gives an extensive subdivision of each chapter in a form convenient for any reference, chapters being subdivided by numbered articles. A good example is furnished by Chapter IV, Column Footings, as follows: Article 25, Types; 26, Proportions of Concrete Materials; 27, Proportioning Concrete to Suit the Materials; 28, Sieve Analysis; 29, Information on Sieves; 39, Void Determination; 31, Proportioning by Scientific Principles; 32, Importance of Consistency and Good Mixing; 33, Concrete of Maximum Density; 34, Consistency of Concrete; 35, Abram's Measure of Consistency; 36, Steel Placing in Footing Slabs; 37, Types of Reinforcement; 38, Problems for Review. A conspicuous, though not important, peculiarity of the text is the very extensive use of bold-faced type for added emphasis or to attract attention.

Volume II, now in press, "Contains a number of jobs, by accomplishing which the worker will learn the how and the why of the elements entering into concrete constructions.

Wage Tables—By Jas. Oliver Hogg, Jr. 4¼ in. by 6¾ in., in leather binding; Jas. Oliver Hogg, Jr., & Co., 536 Rialto Bldg., Kansas City, Mo. $5.

This handbook of wage tables was compiled especially for the building trades. It contains 59 tables of wages, figured to every quarter hour from 1 to 60¾ hours and for rates from 30 ct. to $1.50 per hour.

Wages in Building Trades and American Plan of Employment

To the Editor: We note in the Feb. 9th issue of your paper the statement regarding the future of construction wages You may be interested in noting that the builders of Kalamazoo, Mich., have recommended through their local papers a wage scale which they recommend to the workmen for consideration. You also probably know that in the Feb. 9th issue of the Detroit Free Press, the Associated Builders of Detroit made a definite recommendation that building trades labor should be reduced 20 per cent.

On Feb. 2nd the general contractors and builders of the entire state of Michigan were invited to be, and most of them were present at a meeting helding in Lansing, Mich., for the purposes of organizing a State Association of Building Trades Employers. Committees were appointed and on Feb. 10th. several committees met in Lansing again and formal steps were taken to complete the organization. By-laws were submitted and approved and a temporary Board of Governors elected to undertake the management of the Association until a date in the near future at which the formal election of permanent officers will take place.

The outstanding feature of this meeting was the adoption of the following Declaration of Principles approving the American Plan of Employment:

DECLARATION OF PRINCIPLES

The Associated Building Employers of Michigan declare that in all buildings or other construction work in which in the future they shall be interested, whether as contractors or owners, in the State of Michigan, it is their purpose to adopt and support the American Plan of Employment only.

By the use of the term "American Plan" of Employment we mean that all men shall have equal right to work on any and all projects without regard to affiliation or non-affiliation with organized labor. We consider it the fundamental constitutional right of every employe to sell his services where he may, without fear or hindrance.

A due regard will be held for all contracts for labor commonly known as trade agreements, to which any employer or group of employers has previously subscribed.

In no case shall the Associated Industries of Detroit recognize or support any so called trade agreement that in any way attempts to destroy or defeat the American Plan of Employment.

Where any tradesman working under a so called trade agreement shall interfere with or intimidate by sympathetic strike or otherwise workmen in other trades or shall hinder them in the execution of their work, such tradesmen shall be considered as acting in contravention of the American Plan of Employment and the parties signing this Declaration will lend every support and assistance within their power to employers affected by such breach of agreement.

H. L. CONRAD, Manager,
H. G. Christman Co.

Lansing, Mich.

The Trend Toward the Engineer

The present-day whirlpool of [illegible] and opinion may appear to the casual [illegible] to be a hopeless [illegible] of conflicting currents and [illegible]. The skilled observer, however, detects the formation of two unmistakable and encouraging trends. One is the constantly increasing public interest in industrial economics. The other is the constantly increasing appreciation of the trained engineer as a principal factor in industrial management.

These two trends are not only of [illegible] importance and closely related to each other, but they also have vital bearing in their individual and collective relationships, to the "burning questions of the day" such as that of the open or closed shop, the restriction of immigration, and the general relations between capital and labor. So important are these trends in their bearing upon the principal subjects of interest to industrial managers that it is worth while to develop the subject step by step.

Industrial topics today are considered by the public press of first-page importance. Hardly a day passes without the appearance in the American press of many columns pertaining to industrial economics. Such matters as the open versus the closed shop, collective bargaining, employee representation and kindred subjects, are studied with interest not alone by the parties most immediately concerned, but by the general public as well. This fact assumes its real importance when one reflects that even five years ago such topics rarely were discussed in the general press. In past years during a labor controversy, the two sides would fight it out between themselves. Today the first thought of either party to an industrial controversy is to get its arguments before the public.

This change has been brought about primarily by the war and secondarily by war's effect on the cost of living.

Unfortunately the average layman is not sufficiently conversant, with economic truths and principles to be able to invariably sift the chaff from the wheat. And so a fair proportion of the industrial economics presented in the public press is propaganda based on or at least influenced by the special interests of one class or another. Public opinion, to which both capital and labor turn with increasing frequency as an arbiter in industrial matters, is therefore somewhat in the position of an English speaking juror trying to decide between foreign litigants. It needs an interpreter.

This same period which established the trend toward the public discussion of industrial matters has also forced the trained engineer more or less without his volition, to take an increasingly important part in management economics. Ten years ago executives who were engineers were comparatively few and far between. Today they are fairly common. Ten years from now they will, perhaps, be the rule. Sam A. Lewisohn in "Industrial Leadership and the Manager" (The Atlantic Monthly, September, 1920), calls attention to this trend in the following words:

> It is therefore particularly interesting to note that more and more of those who are given the responsibility of managing our local plants are graduates of technical schools. It is becoming each year increasingly evident that a large part of the industrial leadership of the country must come from such engineer-managers, who have succeeded the old owner-managers. . . . The old-fashioned owner-manager has too often been hampered in the handling of his employes by the conventions of his class. He may have been human, but surely it has been a dogmatic humanity. On the contrary, the scientific approach of the engineer is unfriendly to intolerance. Above all, he is taught to be thorough and open-minded. Engineer-managers who have combined with their knowledge of the material sciences a scientific study of human relations are usually superior to other industrial managers in their approach.

Note that Mr. Lewisohn describes the quality of "open-mindedness" possessed by the engineer as that responsible for bringing about this trend.

The recognition of the trained engineer as a prime factor in management is further emphasized by the election of Herbert Hoover, on November 19, 1920, to be president of the American Engineering Council, the purpose of which is to encourage active participation by American engineers in the solution of broad economic and industrial problems. In his inaugural address, Mr. Hoover spoke in part as follows:

> [illegible] apart from control of capital and service, during the last score of years, has been the great growth and consolidation of voluntary local or national associations. We [illegible] the growth of great employers' associations, great farmers' associations, great merchants' associations, great bankers' associations, great labor associations, all groups striving by political action, propaganda and other measures to advance group interests.
>
> If the engineers can be of service in bringing about co-operation between these great economic groups they will have performed an extraordinary service. The engineers should be able to take an objective and detached point of view. Their calling in life is to offer expert service in constructive solution of problems to the individuals in any of these groups.

Note that here again we have the emphasis of the quality of "open-mindedness" together with the warning of the danger of unco-ordinated organization.

Again, and from an entirely different angle, we have the viewpoint of organized labor as expressed on November 18, 1920, by Matthew Woll, vice-president of the American Federation of Labor, who said:

> The viewpoint of the engineer is valuable because it is a viewpoint of a man whose position is such as to enable him to see the whole broad problem involved. He is in a position to know fully the value of being able to release the creative energy of workers to bring into play their interest and intelligenc.

So we have Mr. Lewisohn, who may be taken as representing capital, Mr. Hoover, representing broad-minded management, and Mr. Woll, representing organized labor, all uniting in the belief that the engineer can play a most important part in shaping our industrial affairs, and each of them ascribing "open-mindedness" as the reason for this capability.—From an editorial in Industrial Management.

Properties of Ordinary Wood Compared With Plywood

Wood, as is well known, is a non-homogeneous material, with widely different properties in the various directions relative to the grain. This difference must be recognized in all wood construction, and the size and form of parts and placement of wood should be such as to utilize to the best advantage the difference in properties along and across the grain. Were wood a homogeneous material such as cast iron, having the same strength properties in all directions that it has parallel to the grain, it would be unexcelled for all structural parts where strength with small weight is desired.

The U. S. Forest Products Laboratory has found that the tensile strength of wood may be 20 times as high parallel to the grain as perpendicular to the grain, and its modulus of elasticity from 15 to 20 times as high. In the case of shear the strength is reversed, the shearing strength perpendicular to the grain being much greater than parallel to the grain. The low parallel-to-the-grain shearing strength makes the utilization of the tensile strength of wood along the grain difficult, since failure will usually occur through shear at the fastening before the maximum tensile strength of the member is reached.

The large shrinkage of wood across the grain with changing moisture content may introduce distortions in a board that decrease its uses where a broad, flat surface is desired. The shrinkage from the green to the oven-dry conditions across the grain for a flat-sawed board is about 8 per cent, and for quarter-sawed board about 4½ per cent, while the shrinkage parallel to the grain is practically negligible for most species.

It is not always possible to proportion a solid plank so as to develop the necessary strength in every direction and at the same time utilize the full strength of the wood in all directions of the grain. In such cases it is the purpose of plywood to meet this deficiency by cross banding, which results in a redistribution of the material.

In building up plywood a step is made in obtaining equality of properties in two directions, parallel and perpendicular to the edge of a board. The greater the number of plies used for a given panel thickness, the more homogeneous in properties is the finished panel. Broadly speaking, what is gained in one direction is lost in the other. For a very large number of plies it may be assumed that the tensile strength in two directions is the same and that it is equal to the average of the parallel-to-the-grain and perpendicular-to-the-grain values of an ordinary board.

Analysis of Cost of Elements Entering into Construction of a Reinforced Concrete Building

An interesting analysis of the relative effect on cost of variations in the proportions, dimensions and floor loading for a reinforced concrete building was given by Mr. J. Morrow Oxley, in a paper presented Feb. 2 at the general professional meeting at Toronto of the Engineering Institute of Canada.

The method employed was to study first the main elements individually, then to combine them into a complete building, and finally to make applications to specific problems. Only the structural elements were considered in the study, an abstract of which follows:

Type of Building and Design Features.—The type considered was a flat slab reinforced concrete building, with brick spandrel walls, solid metal sash glazed with clear glass, concrete coping and sills, cast in place, five-ply felt and gravel roof, cement finish on floors, and reinforced footings resting on firm soil. This type was chosen for the first study as one that is well standardized in both general and detail construction and readily adaptable to practically all classes of light manufacturing and storage occupancy.

The slab design was based on the Chicago Building By-law Regulations of Jan. 1, 1918, with a slight modification of the bending moments in the slab justified by more recent analysis of the conditions. Columns and footings were designed according to the report of the American Joint Committee on Reinforced Concrete 1916. The above specifications were chosen as it was considered that on the whole they have met with a more general acceptance than any others available.

The working unit stresses and moment constants used are tabulated below.

UNIT STRESSES EMPLOYED.

Footings—	
Pressure on soil	4 tons per sq. ft.
Punching shear on conc.	120 lb. per sq. in.
Tension on steel	= 16,000 lb. per sq. in.
Bond on steel (deformed)	100 lb. per sq. in.
Columns—	
1:2:4 mix (unhooped)	
Comp. on conc.	450 lb. per sq. in.
Comp. on steel (n = 15)	= 6,750 lb. per sq. in.
1:1:2 mix (hooped)	
Comp. on conc.	= 1,050 lb. per sq. in.
Comp. on steel (n = 10)	= 10,500 lb. per sq. in.
Slab and beam (1:2:4 mix)	
Comp. on conc.	= 750 lb. per sq. in.
Tension on steel	= 18,000 lb. per sq. in.
Diag. tens. on conc.	= 60 lb. per sq. in. (on vert. sect. bjd.)
Punch shear on conc.	120 lb. per sq. in.
$n = \frac{E_s}{E_c}$	= 15
d = effective depth.	
k = depth to neut. axis	= 0.384 d
j = centroid comp. to centroid tens.	= 0.872 d
Moment of resistance conc.	126 bd^2
Moment of resistance steel	Area steel × 15,000

MOMENT CONSTANTS.

W = Total live and dead load on panel.
W_1 = Total live load only on panel.
L = Panel length c. to c. columns.

Type of panel.	Half panel width centered at column. Neg. mom. over col. capital.	Half panel width centered at column. Pos. mom. at mid-span	Half panel width centered at mid-span. Neg. mom. over straight band	Half panel width centered at mid-span. Pos. mom. at mid-span
Interior	$\frac{WL}{30}$	$\frac{WL}{75}$	$\frac{WL}{125}$	$\frac{WL}{125}$
Wall panel supported on conc. cols. and girders	$\frac{WL}{30}$	$\frac{WL}{60}$	$\frac{WL}{125}$	$\frac{WL}{100}$

MOMENT CONSTANTS ON COLUMNS

Int. column carrying roof	$\frac{W_1L}{30}$
Int. column carrying floor	$\frac{W_1L}{60}$
Wall column carrying roof	$\frac{WL}{30}$
Wall column carrying floor	$\frac{WL}{60}$

Method of Analysis.—All costs noted represent total cost to the owner of the building. Except for the items of some of the individual elements, costs are expressed in relation to the square foot of floor area as it is believed that this gives a more useful and commercially applicable result than the cubic foot basis. Except for buildings of the 1-story mill type where the cost of walls is a relatively large part of total cost, it is considered that cost figures based on floor area are a truer index than those based on cubic contents.

The unit prices used in compiling the tables and diagrams are tabulated below. They are based on tenders received for various buildings in Toronto in the fall of 1920. Of course with changes in the prices of materials and labor these unit prices would vary, but as the purpose of the present analysis is to show the relative not the absolute costs of the features considered, the unit prices are of secondary importance as long as their relation one to another is approximately correct. This feature will be dealt with later in the form of an "index" figure which may be used to arrive at absolute costs in spite of variations in unit prices.

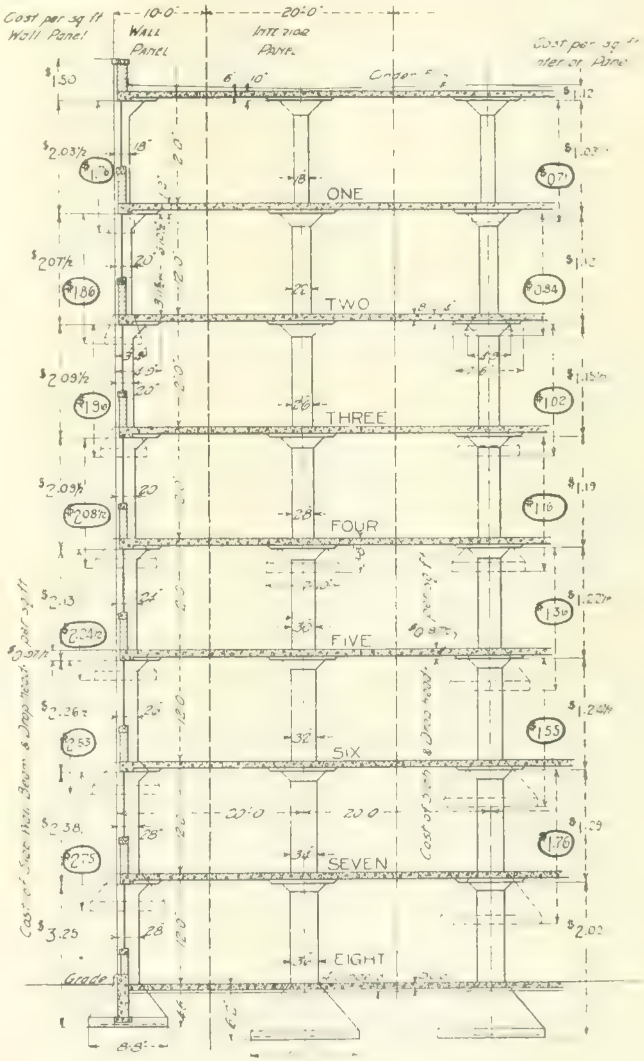

Fig. 1—Partial Cross Section.

UNIT COSTS EMPLOYED.

Flat Slab Const.—		
6 in. to 9 in. slab		
Conc., per cu. ft.		$0.[illegible]
Steel, per lb.		.08
Forms, per sq. ft.		.20
		.14
Cols. conc., per cu. ft.	1:1½:3	.59
	1:1:2	.64
Col. forms, drop, each		9.25
Cap, each		3.90
Per sq. ft.	square	.25
	oct.	.30
	round	.40
Cement Floor Finish—		
Laid with slab, 1 in. thick		.02
Laid after, 1½ in. thick		.0[illegible]
Brick spandrels, 9 in. thick, per super. ft.		.64
13½ in. thick, per super. ft.		.88
Roofing, per sq. ft.		.16
Flashing, per lin. ft.		.465
Coping, per lin. ft.		.465

Sills, per lin. ft.	[illegible]
Sash in place, not glazed, per sq. ft.	.85
With wire glass, per sq. ft.	1.0
Ground Floor:	
Finish, per sq. ft.	$0.07
5 in. conc., per sq. ft.	[illegible]
6 in. cinders, per sq. ft.	.08
Grading, per sq. ft.	.03
	$0.11
Footings:	
Excavation, per cu. yd.	$1.00
Concrete, per cu. ft.	.50
Forms, per cu. ft.	.20
Steel, per lb.	.075

A typical section of one building has been worked out in detail and by the use of the diagrams corresponding cost items may be found for other buildings of different heights, panel sizes and floor loadings. The building chosen for detailed study has panels 20 ft. square, live load on floors of 200 lb. per square foot; it has a story height of 12 ft. and is 8 stories high. A partial cross section and floor plan with some particulars as to reinforcement, etc., are shown in Figs. 1 and 2.

Cost of Footings.—The cost of footings, including excavation, has been computed in relation to the column head. Fig 3 shows these costs in terms of total cost of single footings for a given column load, and Fig. 4 shows them combined with columns in terms of cost per square foot of floor carried. It was found that except for the very light loads the depth of footing was determined by the unit stress in punching shear, which was measured on a cylinder of the perimeter of the column. Bond stresses were figured from vertical shear and necessitated the use of rods smaller than base price sizes up to column loads of about 850,000 lb. Some discussions which have appeared in the technical journals since the preparation of these diagrams might justify the use of a truncated cone section instead of a cylinder as the criterion for punching shear, and permit of a more even distribution of bond stress over the length of the rod. Both these points would tend to reduce the cost of the footings somewhat.

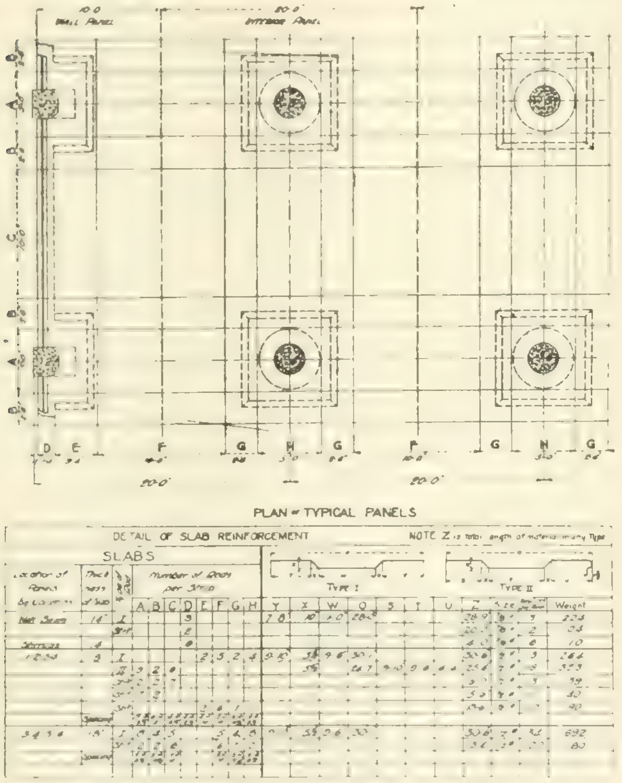

Fig. 2—Floor Plan.

Cost of Various Types of Columns.—A comparison of the relative values of different types of columns was made to show definitely the advantage of using a hooped column and a rich mix. This is based on 24-in. columns, with 1 per cent longitudinal steel and hooping equivalent to 1 per cent of the volume of the enclosed concrete. The concrete outside the steel is not considered as effective section. Costs are stated in terms of the cost in cents, of carrying a load of 1,000 lb. a vertical distance of 1 ft. The weight of column is given in the same terms.

These tabulations show the economic value of using hooping and a rich mix, particularly in a high building, where the weight of the column itself will be an important item as the lower stories are reached. This table shows that for a given load carrying capacity the type of column that a few years ago was considered standard, not only costs 71 per cent more than the minimum type but also weighs more than twice as much. It also shows, by means of the items for an additional 1 per cent of longitudinal steel, the relative extravagance of using more steel than the allowable minimum.

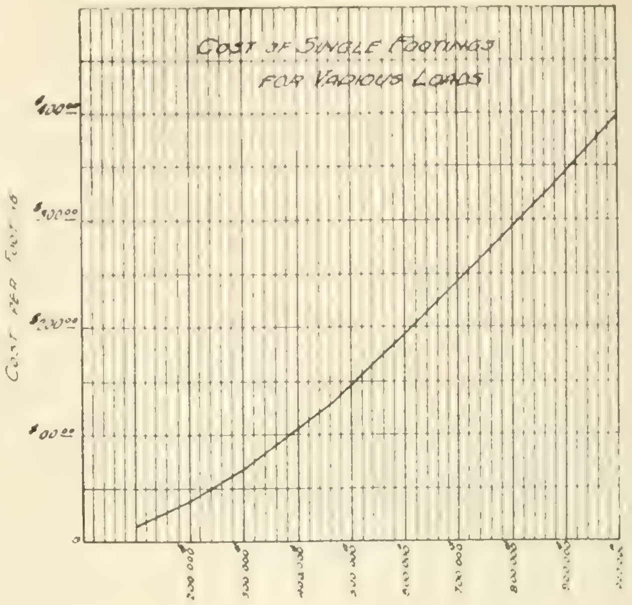

Fig. 3—Cost of Single Footings for Various Loads.

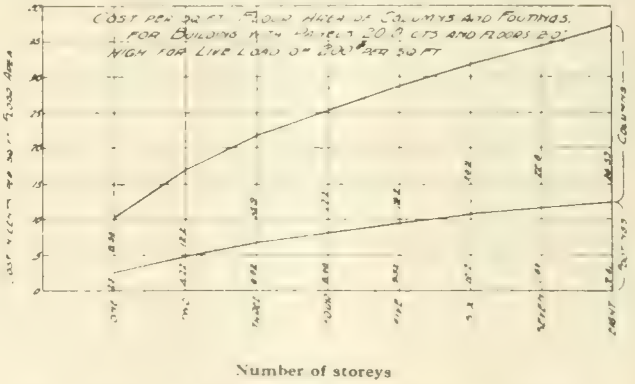

Fig. 4—Cost per Square Foot of Columns and Footings.

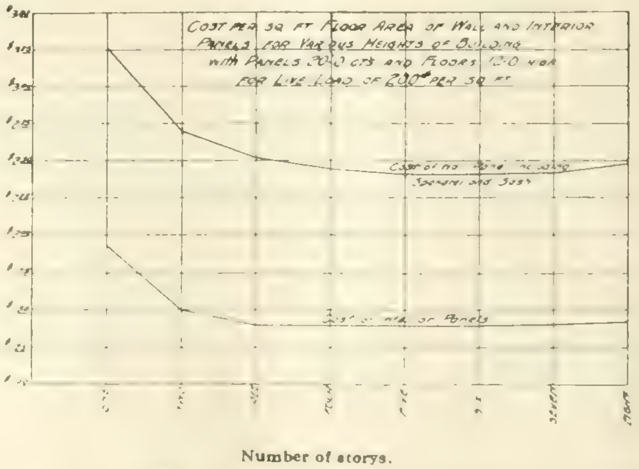

Fig. 5—Cost per Square Foot of Floor Area of Wall and Interior Panels.

The item of cost for the additional 1 per cent of longitudinal steel is the cost per 1,000 lb. for the additional load which the more heavily reinforced column is capa[illegible]rying.

Of course the necessity of keeping columns within a [illegible]able size, and, in some cases, the provision for bending moments, will frequently make it advisable to use more than the minimum of steel. In one building for which the general cost amounted to about $2.50 per square foot it was found that the addition of sufficient steel to keep the maximum column side down to 24 in. amounted to $20 per square foot of floor space gained.

COST OF COLUMNS OF VARIOUS TYPES

Type.	Mix.	Weight per ft. per 1,000 lb. carried.	Cost per ft per 1,000 lb. carried.	[illegible] minimum [illegible]
24 in. diam. round hooped. Long steel = 1%	1:1:2	1.27 lb.	1.58 ct.	100
	Add 1% steel		2.7 ct.	
	1:1½:3	1.49	1.81	[illegible]
	Add 1% steel		[illegible]	
	1:2:4	1.81	[illegible]	[illegible]
	Add 1% steel		2.61	
24 in. sq. ties @ 12 in. ctrs. Long steel = 1%	1:1:2	2.01	1.93	[illegible]
	Add. 1% steel		[illegible]	
	1:1½:3	[illegible]	2.21	140.0
	Add 1% steel		[illegible]	
	1:2:4	2.95	2.70	171.0
	Add 1% steel		4.05	

Comparative Costs of Slabs.—For purposes of comparison a table has been compiled showing the cost per square foot of slabs composed of various concrete mixes. This table is based on a slab or beam designed for a given live load, and as the dead load increases with the greater depth of slab required for the leaner mixes the total bending moment increases correspondingly.

An application may be made of the tables to find at what height above footings it would pay to use a richer mix for the slab than the normal 1:2:4.

Consider a panel 20 ft. square, area 400 sq. ft. A slab of 1:1½:3 mix would cost 400 × 1.1 ct. = $4.40 more than one of the same strength in a 1:2:4 mix, but would weigh 400 × 8 = 3,200 lb. less. The saving in column cost per foot of height would be 1.58 × 3.2 = 5.06 ct. So the column height of $\frac{440}{5.06}$ = 87 ft. the saving in column cost would balance the higher slab cost, and at any height above this there would be some economy in using the richer mix for the slab.

Application to Complete Building.—The curves of Figs. 5 and 6 represent costs computed for what may be considered an average type of building as illustrated by Figs. 1 and 2. These curves cover the range of probable variations in width and number of stories. They are prepared from the amounts shown on Fig. 1 which, it will be noted, are in two series. The items on Fig. 1, enclosed in the rings represent the square foot cost for each tier when it becomes the lowest story of the building, while the unenclosed items are for the tier when it is an upper story.

The method of computing these items was first to work out the actual costs of an 8-story building. Then for each floor in turn the saving in floor slab construction is deducted, and the footing cost is added, to arrive at the unit cost when the floor in question is considered as the ground floor. Thus to arrive at the average cost of, say, the wall panel of a 4-story building we add together the unenclosed figures for roof, one, two and three stories and the enclosed figure for the fourth or ground floor totaling $9.79. Divide the sum by the number of stories, four, and we have the average cost per square foot, equals $2.45.

The wall panel has been considered as extending only to the mid-span. This gives a convenient arrangement, as then an interior panel may be considered as the area centered on a single column, and any number of interior panels may be added to two wall panels to produce the total for any width of building. In the costs for the wall panels are included the costs of the extra steel in the slab required for the greater bending moment, the wall beam, the brick spandrel, and the sash.

The cost per square foot of a corner panel, which has an area equal to one-half that of an ordinary wall panel, but a wall length and column cost equal to that of a wall panel, will be very nearly the same as the sum of the wall and interior panel costs for the corresponding floor. Thus for a 4-story building, the square foot costs of wall and interior panels taken from Fig. 5 are $2.45 and $1.40, respectively. The sum of these gives us $3.85 per square foot. The area of the corner panel will be 10 ft. × 10 ft. = 100 sq. ft. per floor, and this item may be added to the amounts made up from complete wall and interior panels to get the total for the whole building.

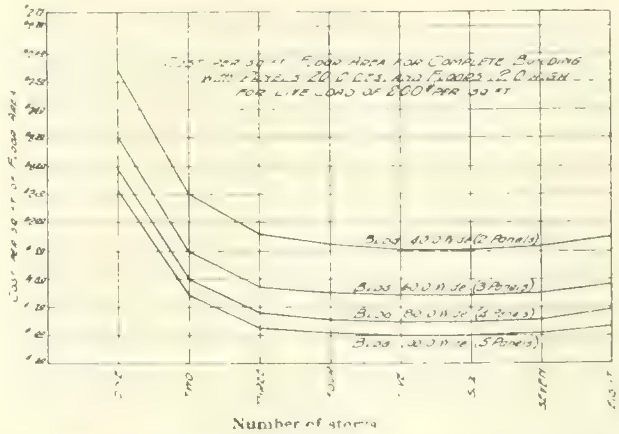

Fig. 6—Cost per Square Foot of Floor Area for Complete Building

Application of Curves to Practical Case.—The applications of these curves may be made clearer by consideration of a practical case.

An owner requires 256,000 sq. ft. of space for light manufacturing, of which he wants one-half built at present and the remainder at some future date. The building has unobstructed light from both sides and so may be fairly wide, say, 80 ft. Compare two possible solutions.

Case I—Building 80 ft. wide, 400 ft. long, four stories high, designed for a future addition of four stories.

Case II—Building 80 ft. wide, 200 ft. long, eight stories high, with provision for an extension at one end 200 ft. long.

For Case I we shall have to go back to the table of unit prices for the items of parapet and the temporary roofing and fill. The cost of the top floor slab without finish, columns or walls, and the items for interior and wall panels for the one, two, three and four tiers, counting from the top, will be

COST OF 1 SQ. FT. OF SLAB DESIGNED FOR B. M. FROM L. L. OF 200 LB. PER SQ. FT. OF 30,000 LB. IN STRIP 12 IN. WIDE

Mix.	Total B.M. LL + DL	d $\sqrt{\frac{BM}{12RM}}$	Wt. of slab per sq. ft.	Concrete cu. ft.	Steel, sq. ins.	Conc. + steel	Finish and forms	Total cost in cts. per sq. ft.	Per cent of min. cost
1-3-6	30,000 16,500	7.85 (+ 1")	110 lbs.	[illegible]	[illegible]				
	46,500			= 35.5	10.2	45.7	37	82.7	[illegible]
1-2½-5	30,000 13,500	6.35 (+ 1")	[illegible]	[illegible]	[illegible]				
	43,500			= 30.5	11.5	42.0	[illegible]	[illegible]	[illegible]
1-2-4	30,000 12,000	5.27 (+ 1")	[illegible] lbs.	[illegible]	[illegible]				
	42,000			= 28	13.6	41.6	37	78.6	100
1-1½-3	30,000 10,500	4.65 (+ 1")	70 lbs.	[illegible]	[illegible]				
	40,500			= 27.6	15.1	42.7	37	79.7	100
1-1-2	30,000 9,500	4.20 (+ 1")	65 lbs.	0.433@64c	0.605@27c				
	39,500			= 27.6	16.3	[illegible]		[illegible]	103.0

found on Fig. 1. The two cases [illegible] as follows:

CASE I.

[illegible]	$ 1,334
[illegible]	258
[illegible]	5,280
[illegible]	6,400
	$13,272

Cost	Interior.	[illegible]	[illegible]
Top	$0.87½	[illegible]	[illegible]
One	1.2[illegible]	[illegible]	[illegible]
Two	1.34½	[illegible]	[illegible]
Three	1.5[illegible]	[illegible]	[illegible]
Four	2.02	[illegible]	[illegible]
Totals	$6.65½	11.00	16.8[illegible]
Area	22,800	8,800	400
Amount	$151,734.00	$96,800.00	$6,742.00

Total for floors (everything below roofing)	255,276
Total for building	$268,548
Total area 128,000 sq. ft.	
Cost per sq. ft.	$2.10

CASE II

For Case II, with the exception of the end wall panels, this may be taken directly from Fig. 6 where we find the cost for an 8-story building 80 ft. wide to be $1.69 per square foot.

Floor area omitting end wall panels is 80 × 180 × 8 = 115,200 sq. ft. at 1.69	$194,688
End wall panels give [illegible] of 10 × 20 × 6 × 8 stories = 9,600 sq. ft. at 2.48 = ...	23,608
And 4 corner panels give 10 × 10 × 4 × 8 stories = 3,200 sq. ft. at 3.905	12,496
Total cost	$230,792
Total area 128,000 sq. ft.	
Cost per sq. ft. = ...	$1.80

Thus it is found that Case I will cost 30 ct. per square foot or nearly 17 per cent more than Case II. Another point to be considered is that the roofing on Case I will have to be discarded before having given full service if the addition is made in a few years, while in Case II it will probably be desirable to retain the end wall as a fire wall even when the addition is made.

Effect of Live Load on Cost.—Fig. 7 shows the effect of variation in live load on the cost of a typical interior panel including columns and footings, in a 4-story building. It will be noted that the relative costs are given in percentages referred to the typical building shown in Figs. 1 and 2 and for which he can get dollars and cents costs from Fig. 6.

It is interesting to note what a relatively small increase in costs is caused by a large increase in load carrying capacity.

Effect of Variation in Panel Size.—Figure 8 shows the effect of variation in panel size on the cost for interior square panels, including columns and footings. The percentages on this figure are also referred to the costs on Fig. 6.

By the use of Figs. 6, 7 and 8 it is possible to compare the cost of any probable combination of length, width and number of stories for the type of building considered, and find without great labor, the most economical solution of the problem of supplying an owner with a given amount of floor area. Or they may be applied to balance the cost of various solutions against other considerations, such as the cost of land available, the size and usable area of the lot, architectural considerations, effect of width on natural lighting and so on.

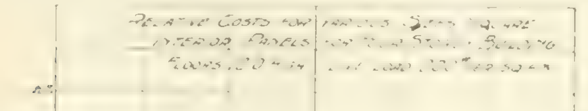

Fig. 7—Relative Costs for Various Sizes Square Interior Panels.

As stated earlier, the dollars and cents costs may not be of direct application owing to the continuous variation in material and labor prices, and the eagerness or otherwise of contractors to take on a job, but it is hoped that the relative costs may be of some use to others as they have been, in a cruder form, to the writer.

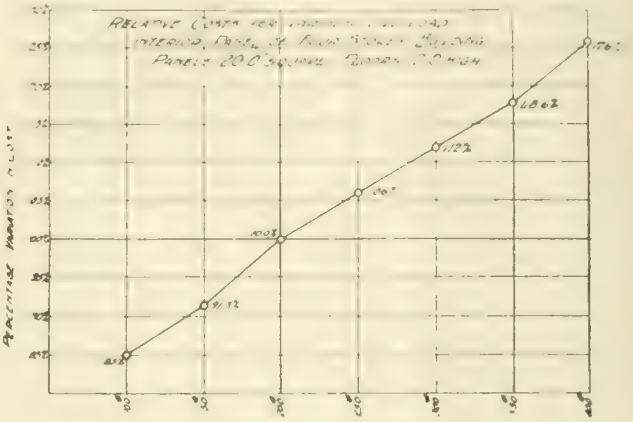

Fig. 8—Relative Cost for Various Live Loads.

Comparative Bidding Prices 1917-20 on Warehouse Building

Interesting comparative costs for several years as indicated by actual competitive bids on a building, are given in a recent issue of the Monthly Bulletin of the Illinois Society of Architects by Mr. F. E. Davidson, of Davidson & Weiss, Architects, Chicago. The bids were submitted for a 4-story and basement standard mill sprinklered warehouse building in Chicago, from plans prepared in the office of Messrs. Davidson & Weiss. This building was designed in accordance with the building code of Chicago for a live load of 200 lb. per square foot. The building was to be equipped with a dry pipe sprinkler system. The heating system was to provide heat in the basement, the office section, toilet rooms and for the gravity tank only. Only eight toilet fixtures were provided for in the plumbing system.

A careful analysis of the estimates for the different classes of work will result in some interesting conclusions, states the Bulletin. Particular attention is called to the trend in prices for cut stone, sheet metal, hollow metal doors, elevator doors, glazing, painting, plumbing and heating.

At the time the original proposals were received the owner, while possessiong ample funds to build, and in need of the structure, was of the opinion that the estimates submitted were entirely too high and deferred construction, hoping that costs would be reduced. At various times, as outlined in the schedule, the work was again estimated with the results indicated:

	Aug. 29, 1917	June 18, 1918	June 18, 1919	Sept. 15, 1919	Feb. 3, 1920.	Nov. 9, 1920
Masonry, carpentry and concrete	$ 98,783	$119,288	$135,900	$155,532	$213,000	$207,000
Structural steel and misc. iron	13,468	15,400	16,700	16,300	21,535	19,667
Cut stone	1,195	1,965	2,438	2,792	3,748	4,075
Sheet metal	240	282	460	360	475	507
Hollow metal stair doors	2,100	2,130	2,421	2,121	2,522	3,45[illegible]
Elevator doors	2,400	2,450	2,580	2,880	3,700	[illegible]
Fire escapes	2,428	2,428	2,381	2,518	2,923	2,92[illegible]
Plastering	525	550	570	665	833	1,000
Glazing	1,820	1,645	1,526	1,681	2,524	2,918
Roofing	1,192	1,240	1,380	1,540	2,000	2,580
Vault doors	185	220	250	260	265	290
Painting	2,593	3,140	3,412	3,712	4,327	5,200
Plumbing	5,355	5,782	6,054	6,654	8,538	10,01[illegible]
Elevators	4,740	4,800	4,900	5,100	6,450	6,700
Heating	4,000	4,300	4,500	4,800	6,500	8,000
Electric wiring	2,000	2,000	2,000	2,400	3,000	3,400
Sprinklers	17,500	17,500	18,000	18,900	23,187	23,187
Hardware	500	520	560	575	800	875
Total	$161,024	$185,640	$206,032	$228,890	$308,327	$307,57[illegible]
Cost per sq. ft.	$1.46	$1.68	$1.87	$2.07	$2.80	$2.79
Increase over 1917		15%	28%	41%	92%	91%
Cost per cu. ft....	.097	.114	.124	.132	.187	.186

Accident Prevention in Construction Operations*

By DAVID S. BEYER,
Vice-President and Chief Engineer, Liberty Mutual Insurance Co.

I suppose everyone here has heard something about the "Safety First" movement; it has spread all over the country in the past few years, but maybe some of you still look upon it as more or less "bunk" or a fad that can't last. But let me tell you, gentlemen, a proposition that is adopted year after year by concerns such as the United States Steel Corporation, the International Harvester Co., the Pennsylvania R. R. Co., and Fred T. Ley & Co., and which is carried out year after year, is something more than a fad, it is good business!

I have the accident chart of a Massachusetts plant insured with the Liberty Mutual, that is saving more than $100,000 per year as a result of the application of accident prevention to the reduction of their insurance cost, and it is costing them only a fractional part of this saving to keep up the accident prevention work. Do you think they consider accident prevention a fad? They will tell you it is one of the best investments they have ever made.

Let me explain a little further how this accident prevention proposition works out. Did you ever stop to think that there are two ways of doing nearly everything—a safe—and an unsafe way? Take the simple illustration of a woman getting off a street car; her natural inclination seems to be to step off with her back towards the direction in which the car is moving, and hundreds of accidents have been the result. Street car companies have been trying for years to educate the public to face in the direction that the car is going, and when this is done an accident seldom happens.

In knocking down concrete forms one way is to let the boards lie where they happen to fall, with rusty nails sticking up like snakes in the grass, ready to pierce the foot of the next man that comes along; another way, which takes no longer in the end, is to pile the boards up, so they will not cause a tripping hazard and so the nails will be covered.

Forming safety habits of this kind on the jobs of one contractor resulted in cutting the nail injuries from 80 per 1,000 employees, to 42 per 1,000 employees, or 47 per cent, in two years. It reduced the accidents from handling material 54 per cent, from handling tools 59 per cent, and from falling material 75 per cent. The greater care in guarding and using machines reduced the machine accidents 75 per cent.

How Some Serious Accidents Occur.—Some staging that was being used in putting up the brick wall of a building on a job which we insured, was designed with ample strength to carry the weight of two men and the material that was likely to be piled on one section at a time. An unusual amount of material was heaped up on this section, and then half a dozen men got together to hold some kind of a "party" the purpose of which was never quite clear—although it was before the dry law went into effect and you may have your own suspicions.

The result was that some nails in the bearer pulled out and the whole party dropped to the ground, a distance of about fifteen feet. They were all more or less damaged. As an illustration of where the money in the contracting industry goes these days, I might say that one of these fellows who was a bricklayer, telephoned home and had his wife send down his limousine and chauffeur to take him home!

However, we see how a little caution on the part of the men, a little more watchfulness on the part of the foremen, might easily have prevented this crowd from getting together and overloading the staging, and thus have prevented the accident.

You know one foreman will have his men trained to "stand from under" when a heavy piece of stone or steel work is being lifted; in another gang no attention is paid to this point, and when a hook or chain gives way from some hidden defect or from strain or "fatigue" developed by constant use, somebody who is standing underneath the load goes to the morgue or to the hospital.

Safety a State of Mind.—I might say that accident prevention is "a state of mind," if you will excuse the "high-brow" expression, because it consists in getting every man on the job to form safety habits, so that he will automatically do things in the safe rather than the dangerous way.

This is true in any industry, but it is more especially true in building contracting, where the most important feature of all is habitual caution on the part of every member of the working force.

A typical accident analysis for one of our large contracting concerns, entitled "How Our Men Get Hurt," shows that only 14 per cent of the accidents had anything to do with operating or handling machinery, and for some contracting concerns the machine accidents are as low as 5 per cent of the total.

HOW OUR MEN GET HURT

		Accidents	Per Cent
Vehicles		43	17
Loading trucks and carts	12		
Handling horses	10		
Jumping on and off trucks and carts	[illegible]		
Collisions of autos	5		
Railroad cars	4		
Cranking autos	3		
Handling materials		67	[illegible]
Lumber	24		
Iron pipes and rods	18		
Brick	14		
Stone	11		
Hand tools		32	[illegible]
Hammers, axes, saws	12		
Picks, crowbars, jacks	10		
Wrenches, etc.	10		
Flying particles		15	6
Stone, cement, etc., in eye	6		
Steel chips striking body	6		
Steel chips in eye	[illegible]		
Falls		29	12
From overhead structures	8		
From stagings	3		
On ground level	18		
Power driven machinery		35	[illegible]
Operating hoists, mixers, saws, etc.	[illegible]		
Setting up machines	[illegible]		
Protruding nails		12	[illegible]
Foot injuries	6		
Hand injuries	[illegible]		
Piling materials		11	[illegible]
Blasting		4	2
Electric shocks		2	1
Total		250	100

A few of the construction accidents can be prevented by mechanical guards, railings, toe boards along working platforms, etc., but the provision of such guards should become a habit on the part of the foreman, and the element of personal caution on the part of the men is still a big factor.

Putting Safety to Work.—In order to get accident reduction, it is necessary to "sell" the safety idea to the entire organization. You must do as the man digging a well did—"begin at the top and work down." In other words, the head of the organization must be interested and get back of the movement with snap and enthusiasm. He must pass this interest along to the foremen, and it must finally become a habit with the man on the job, before the big results will be secured.

And let me say right here that the "king-pin" of every safety proposition is the superintendent or foreman on the job. Conditions on a building contract change every day, and unless the foremen are interested in safety and constantly on the lookout to see that the men are trained in safe practices, the accident rate will not come down.

Competitive Records Create Interest.—We have found that the best way to keep up the interest of the superintendent and foreman is to start a little competition, by comparing the results one man gets with those of another man on similar work.

Comparative records of this kind bring out some interesting things besides "gingering up" the interest in safety. The general superintendent finds that the foreman who is careful about the safety of his men is also careful about the work that is being done, and a lot of concerns now tell their men frankly that their safety record will be considered in making promotions.

I recently looked over the list showing the record of about fifty superintendents on contracting jobs; some of them had gone for several months without a single lost-time accident on work employing three or four hundred men. From no accidents, the record ran up to the high limit of seven accidents per hundred men per month. In other words, this last superintendent was "getting" eighty-four out of every hundred men on his force during the year. If he were a trap shooter that is a record of which he might feel proud, but as an accident score, he—well, when he got a letter from the "big" boss commenting on his record; they tell me he has been sitting up nights ever since, framing alibis!

Every man on that list got a personal letter from the head of the concern commending [illegible] criticizing a bad one. My engineers tell me that in several cases the superintendents have suggested on the side that we pass the word along that they are doing their [illegible] it is just a little hard luck that their records are so high.

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*From an address presented at the New Orleans convention of the Associated General Contractors of America.

Of course there is an element of luck in the accidents on a single job from month to month, but when you get every superintendent and foreman to take as much interest in his accident record as he does in the baseball score, he'll come a lot nearer batting 300 in the safety game.

Safety Engineer Valuable.—Where a concern is large enough to justify the expense, we recommend that it have its own safety engineer, who can maintain general supervision over all safety work, compile data on accident analysis, work up competitive charts between different jobs, personally investigate and follow up serious accidents, and in general see that the safety idea is kept constantly before the minds of the men in the field. Two men who have been doing splendid work along these lines in the contracting industry are Mr. L. D. Woedtke, of the Fred T. Ley & Co., Inc., Springfield, Mass., and Mr. F. A. Davidson, Safety Engineer, Dwight P. Robinson Co., of New York. Interesting articles by these gentlemen describing their safety work have appeared from time to time in technical publications.

Safety Talks and Committees.—Where it is possible to get the men together, we give them safety talks illustrated by lantern slides and moving pictures. Such meetings have been found to be most helpful in stimulating their interest and keeping them constantly on the alert.

There are a number of additional safety features such as the safety committee idea commonly used in industrial plants, which can also be applied successfully to contracting work.

Labor Turnover and Morale.—Every time a man is injured, a new man must be broken in to take his place, so accidents increase labor turnover and the cost of hiring and breaking in new men.

Every accident causes demoralization and disturbance among the working force. It is difficult to estimate just how much this amounts to when a serious accident occurs, but you have all seen the workmen gather around a man who has been injured, and talk about it for hours afterward; their attention is distracted from their work.

There is a strange belief that seems to be quite general among workmen that when one serious accident happens, there will be two more, and it is peculiar how often this is the case. So the important thing is to prevent the first accident.

Accident prevention improves the "morale" of the men, and when they feel that the boss is taking an interest in their safety and welfare they give better service.

The public is coming to realize more the necessity for cutting down accidents, and the old record that was once accepted as a matter of course—a death for every floor of a sky scraper—is something that would make us feel ashamed today.

Manual of Standard Wood Construction.—The 8th edition of this book has just been issued by the Southern Pine Association, New Orleans, La. Much additional information for use in designing composite and all-wood structures has been added to in the new edition. This new data includes the following:

Weights and dimensions of bolts and nuts.

Properties of structural steel shapes.

Minimum live floor loads for structures of various purposes.

Safe column loads.

Trigonometric formulas and solution of triangles.

Mensuration—(Surfaces, and Volume of Solids).

Functions of numbers 1 to 500 (squares, cubes, square roots, cube roots, and logarithms).

Natural sines and cosines, tangents and cotangents.

Logarithmic functions (sines, cosines, tangents and cotangents).

Sheet-piling.

Lattice Trusses.

Design for Howe roof trusses.

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182 Municipalities Have City Manager Plan.—The city manager plan of government has been adopted by 180 municipalities with a total population of 3,100,000.

The Builders' Guild—An Experiment in Altruism

Reference has heretofore been made in Engineering and Contracting to the newly developed Guild of British Builders; and the movement is now manifesting sufficient strength to warrant the publication of its prospectus, which is here reprinted in full from the December issue of The Bulletin of the Associated General Contractors.

To the conservative the prospectus suggests much that is highly radical. Further, the success of the movement is so evidently dependent upon the exercise of high motives and the better instincts by many men, that there are inevitable misgivings—even on the part of those who would wish it well. On the other hand there are some men to whom such motives are sufficient, and only experiment can tell whether or not their numbers may become powerful under favorable circumstances. The previous failures of certain experiments in altruistic projects are far from proving that all such must fail; and there is ever at hand the remembrance of "impossibilities" which have fallen before courageous attack.

The promoters are frank in saying that if the project can not win upon its merits it deserves to lose. They are also to be commended for their modesty in leaving their plan open to development, improvement and growth, instead of attempting at the outset to perfect its every detail. In their own words: "The first and immediate duty of the Guild is to mobilize the necessary labor to build the houses so urgently needed by the nation, and to build them in the best possible manner at the lowest possible cost."

THE PRELIMINARY PROSPECTUS OF THE GUILD OF BUILDERS (LONDON), LIMITED.

The Meaning of the Guild.

In industry those who work with their heads and those who work with their hands cooperate to produce the things which all of us need. If conflict and disunion take the place of cooperation, wealth production is hindered and everything the community requires is rendered less abundant and more costly. To secure this harmony of interest is the master problem of the modern industrial state."

We stand today at the beginning of a new period of economic history. The great Trade Unions—no longer mainly defensive and resistive—are awakening to a new conception of their functions; a new vision of creative service.

And the building industry of England will be the first great stable industry to put this new conception into practical shape in the form of the Guild of Builders.

A Guild is a self-governing democracy of organized public service. It is the very embodiment of the "team spirit." In its full development it means a whole industry cleared for action with all sections united for a common purpose—with a new incentive—the organized service of the community, instead of the attainment of profits.

It boldly challenges the industrial traditions of a century, and makes its appeal solely to the best instincts and creative impulses of men. For it is the first industrial organization in history that is set up to give service rather than to get it. Every word that Ruskin or Mazzini uttered on the claims of Duty and the joy of self-expression in free service, finds its echo here. This is the soul of the movement. It stands on a different plane from all other industrial systems, whether controlled by the state, by municipalities, or by consumers. They are the organization of Rights. Guilds are the organization of Duties.

The Call of the Guild.

"It is always possible to enroll the best men on the side of the best idea."—The Venturer, April, 1920.

Rightly planned, a Guild will be the finest piece of industrial organization that we have yet seen. It will summon to its aid the very best ability and talent that our industry can offer. Administrators—Technicians—Mechanics—Workers of every type will volunteer for its service, without thought of monetary gain; conscious that they are entering upon one of the greatest tasks in history; conscious that it needs them and cannot do without them.

The Structure of the Guild of Builders (London), Limited.—The Trade Union Ticket is the certificate of Guild membership. Every member of every branch of the National Federation of Building Trade Operatives and of every other approved group of Building Trade Workers in the District is a Guildsman and has a vote in the election of the Guild Committee. This, in turn, will ultimately form a part of the National Guild of Builders—a great industrial combine for the public service—with full democratic control by all the workers by hand or brain engaged in that service.

The Guild Committee.—The Guild Committee, therefore, will consist of representatives elected by the following Trade Unions or approved groups within the district:

(a) The Trade Unions affiliated to the District Section of the National Federation of Building Trade Operatives.

(b) Any other Trade Unions or groups of Building [illegible] within the district, whether Administrative, Technical, Clerical or Operative, that may be approved by the committee.

Each Trade Union or approved group will elect [illegible].

When there are several Local Committees operating in the district, each of these Local Committees will be represented on the Guild Committee. In this way we shall secure an elected Executive Committee chosen by districts and by crafts.

The Legal Entity.—Each of these members on election [illegible] up a one shilling share in a society registered under the Industrial and Provident Societies Acts, 1893-1913, and entitled—

The Guild of Builders (London), Ltd.—He will also deposit [illegible] his electors a signed, open transfer, thus giving them power to replace him at any time. In this way the Guild Committee becomes a legal entity with power to enter into contracts, and yet the whole of its members are under the control of the industrial democracy they represent. If any Union or Group fails to elect its member by the appointed day, such member may be co-opted by the Society in general meeting.

Objects of the Guild.—The first and immediate duty of the Guild is to mobilize the necessary labor to build the houses so urgently needed by the nation, and to build them in the best possible manner at the lowest possible cost.

The objects as stated in the draft rules, are:

1. To carry on the industry of Builders, Decorators and General Contractors.
2. To undertake all branches of supply, whether as Merchant, Manufacturer or Transporter.
3. To carry on any other work which the Society may think necessary or desirable in connection with the above objects.

From this it will be seen that the Guild is designed ultimately to undertake every branch of the building industry, and to provide its customers with the services of skilled architects and engineers, to purchase and manufacture the materials, to transport them to the site, erect the buildings—and even, perhaps, to furnish them.

Democratic Control in Practice.—The Guild Committee will be responsible for the appointment and removal of managers and for the fixing of their salaries.

It is important to notice here the difference between the Guild practice and that of the self-governing workshops which have so often been set up without conspicuous success. The manager of a self-governing workshop is responsible to his own staff. The Guild Manager, however, is responsible—through the Guild Committee—not only to his own staff, but to the whole of the organized Building Trade Operatives in the district. This gives him security without weakening the full democratic control by the workers.

Remuneration of Guild Committee.—It is suggested that members should be entitled to subsistence allowances, and compensation for lost time and all expenses.

Powers of Appointed Managers.—Whilst it is generally agreed that large powers should be given, it is recognized that this is a matter for the Guild Committee itself to decide, and does not therefore come within the scope of this prospectus.

The New Status of the Guild Worker.—The labor of the Guildsmen will no longer be regarded as a commodity like bricks or timber, to be purchased, or not, as required. As soon as it can be arranged, the Guildsman will be "on the strength" for life. He will draw Guild pay in sickness or accident, in bad weather or in good, at work or in reserve.

The minimum Guild pay will always be the full standard rate as fixed for the industry as a whole, but there is no doubt that the Guild will be able to increase the purchasing power of its members' pay by the scientific organization of production.

Building Contracts.—The Guild will undertake work for every type of building owner, whether public or private. It will build for agreed prices or for prime cost plus a fee. But in every contract the price or the fee must include the percentage necessary to secure during its run, to all engaged thereon, the continuous Guild pay described in the last paragraph.

Beyond this there will be a small percentage for the purchase of plant, for overhead charges, and, if necessary, for the hire of capital, at fixed rates, without powers of control.

Organized Public Service.—This is the watchword of the Guild. It means that its surplus earnings will under no circumstances be distributed as dividends. This is a fundamental rule. Surplus earnings will always be used for the improvement of the service, by providing for increased equipment, for reserve, for technical training and research, and for the elimination of hired capital.

Ownership of Plant and Material.—It is intended that all plant and material shall be transferred to the properly constituted authority to be set up in connection with the National Guild of Builders.

Craftsmanship.—"We shall do work worthy of the middle ages," said one of the Manchester operatives to whom the Guild Movement owes so much, and he was right. The Guild stands for the revival of the building art. It will offer scope to the craftsman such as he has never dared to hope for. It opens out possibilities of service to the skilled administrators and technicians that the old system could not possibly provide. And it gives them all a new status as free men, working in a democratic comradeship of service.

Financial Guarantees.—The Guild will give no financial guarantee for the performance of its contracts. It pledges itself to carry out the work that it undertakes and it supports this with a roll of volunteers pledged to do the work. This is the most effective guarantee that can be devised.

The Call for Volunteers.—A form of enrollment will be found at the end of this prospectus, and all building trade workers of every grade are invited to sign it, and at the same time to subscribe to the Journal of the Guild, and to the loan for preliminary expenses.

The Journal.—The Guild Journal is an essential feature of the scheme. It will keep all the Guildsmen informed as to the progress of the movement. It will follow closely the proceedings of the Building Trades' Parliament before which the Guild proposals will be frequently debated. It will illustrate the buildings erected by the Guild, describe new methods and new processes, circulate statistics, publish correspondence, and, above all, it will be recognized and read by the public as the official organ of the New Industrial Democracy.

Will the Guild Work?—"No one who has ever risen to any great height in this world has refused to move until he knows where he is going. Here is the great spiritual weakness of our time; we have lost sight of the venturesomeness of Faith. But somebody has got to break away—somebody has got to break the spell of things as they now are, if we are not to go on in a cycle of increasing tragedies. How can we go without knowing whither? How can we lose without seeing any acquisition?

"If Columbus had reflected thus, he would never have weighed anchor. It is madness to sail the sea without knowing the way; to sail the sea no one has ever traversed before; to make for a country the existence of which is a question.

"But, with this madness, he discovered a New World."

Identification of Oak Woods

Over fifty species of native oaks assume the proportions of trees, and about twenty-five are used for lumber. After the oaks are cut into lumber, there is no means known to the U. S. Forest Products Laboratory by which they can be identified as to exact species. By examination of the wood alone, however, it is easy to separate the oaks into two groups—the white oaks and the red oaks; and for most purposes, fortunately, it is not necessary to classify them any further. The oaks all average about the same in strength, but those in the white oak group are more durable under conditions favorable to decay than those in the red oak group.

The white oak group includes true white oak, swamp oak, burr oak, cow oak, post oak, overcup oak, and chestnut oak. The red oak group includes true red oak, yellow or black oak, scarlet oak, Spanish oak, Texan oak, black jack, water oak, willow oak and laurel oak.

The color of the wood is a ready but not absolutely reliable means of distinguishing the white oaks from the red oaks. Red oaks usually have a distinctly reddish tinge, especially near the knots. The wood of the white oaks is generally a grayish brown, but occasionally a reddish tinge is found in white oak lumber.

For more accurate identification it is necessary to examine the pores of the wood. These will be found as tiny holes on a smoothly-cut end surface, the largest being visible to the unaided eye. They are not of uniform size throughout each growth ring, but are considerably larger in the wood formed in the spring, decreasing in size rather abruptly towards the summer wood. The large pores in the springwood of the heartwood and inner sapwood of the white oaks are usually plugged up with a froth-like growth called tyloses, and those of the red oaks are open. This feature, however, is not so reliable for classification as the character of the much smaller pores in the summerwood.

To tell for a certainty whether a piece of oak belongs to the white or red oak group, cut the end grain smoothly with a sharp knife across several growth rings of average width. With the aid of a hand lens examine the small pores in the dense summerwood. If the pores in this part of the growth ring are plainly visible as minute rounded openings, and are not so crowded but that they can readily be counted, the wood belongs to the red oak group. If the pores in the summerwood are very small, somewhat angular, and so numerous that it would be exceedingly difficult to count them, the wood belongs to the white oak group.

Concrete Road Methods Applied to Construction of Factory Floor

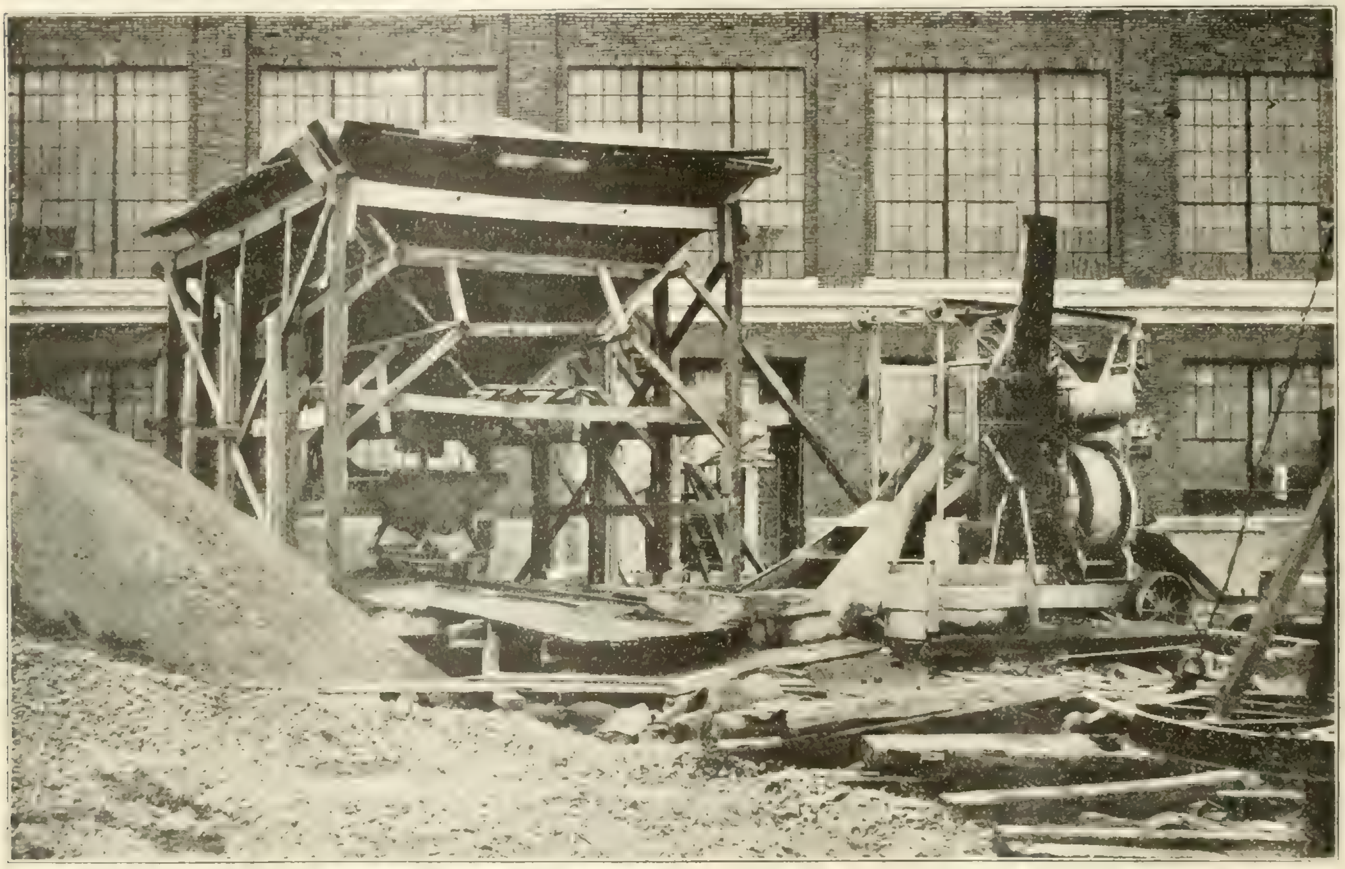
Concrete road methods, including finishing by the use of the roller and curing by ponding, were employed in constructing 225,000 sq. ft. of concrete floor in the additions to the plant of the A. O. Smith Corporation, manufacturer of pressed steel products, at 27th St. and Keefe Ave., Milwaukee, Wis.

The addition measures 360 ft. by 846 ft., and extends a distance of three city blocks. The equipment used for constructing the floor consisted of a Koehring No. 10E paver, specially constructed hopper bins equipped with side dump car, one Hayward clamshell bucket and two Clark tructractors. A gang of 70 men was employed.

The tructractors were used in delivering the mixed aggregate. The boom and bucket of the paver was removed and the concrete discharged directly into the trucks at maximum speed. The trucks carried the mixed concrete into the building and to the place of deposit, where they were quickly dumped by the driver, the boxes being front-tilting. About 114 trips per day of 7½ hours were made by each truck, making approximately one round trip every four minutes.

The entire operation of mixing, discharging and carrying the concrete to the place of deposit was so planned that no time was wasted, one operation following another with precision. While one truck was carrying a batch of concrete, another batch was being mixed in readiness for the second truck, which was returning to the mixer after having discharged its load. No time was wasted either at the place of deposit or at the machine.

After finishing the concrete floor, an inch or two of water was poured on it in order to allow the concrete to harden more slowly and become stronger. The water remained for three or four weeks before being drained.



Hopper Bins, Side Dump Car and Mixer. With This Arrangement Only Two Men Were Required to Get Aggregate From Bins Into Mix.

Sand and gravel were delivered by freight cars, spur tracks being laid alongside the new building. The clamshell operated from a stiff-legged derrick then transferred the materials to a large hopper bin, divided into two sections in order to keep the sand and gravel separate. A platform, on which a narrow gage track was laid, was built beneath the bins. A side-dump car on this track carried the materials from the bins to the mixer. Two men filled the car, pushed it over the platform and dumped it into the charging skip of the paver, which was conveniently placed directly alongside the platform.

Cement was the only material not handled with the aid of machinery. One man hauled it by wheelbarrow to the mixer and another emptied it into the skip; the second man also acted as fireman of the mixer, which was equipped with steam engine and boiler. By the use of this plan full advantage of mechanical devices was taken in substituting them for labor. Instead of the crew of men ordinarily required for handling the aggregate, a total of only five men in conjunction with these devices was necessary in placing materials into the charging skip; these included one operator of the derrick, the two men at the hopper bins, and the two cement men, one hauling and one emptying it into the skip. One engineer operated the mixer.

The best day's record was 9072 sq. ft. of concrete floor in 7½ hours, and the average for several weeks was over 7000 sq. ft. per day of 7½ hours.

The contractor for this work was the Jacobus & Winding Concrete Construction Co., Wauwatosa, Wis.

Wholesale Prices in December

A sharp decline in the general level of wholesale prices in the United States was again manifested in December, according to data gathered in representative markets by the Bureau of Labor Statistics of the U. S. Department of Labor. The Bureau's weighted index number, which assigns to each commodity an influence proportionate to its importance in the country's markets, declined to 189 in December, a drop of 8¾ per cent from the November price level and 30½ per cent from the high peak of prices in May.

Farm products and foods again showed large price recessions, the figures for these two groups being 12¾ per cent and 11¾ per cent, respectively, below those of the previous month. Chemicals and drugs followed next in order, with a decrease of 9¼ per cent. Fuel and lighting mat[illegible] 8½ per cent and metal products were 7½ per [illegible] than in November, while house-furnishing good[illegible] laneous commodities, the latter group including such important articles as cottonseed meal and oil, millfeed, manila hemp, rubber, soap, paper, lubricating oil, and wood pulp, each averaged over 6 per cent of decline from November prices.

Cloths and clothing were about 6 per cent cheaper in December, while building materials showed the smallest decrease of all—approximately 3 per cent. In no group was the level of prices as high as in the preceding month.

Of 326 commodities or price quotations included in the comparison for November and December, 219 showed a decrease and only 13 showed an increase. In 94 cases, no change in price was recorded. Of these, a majority belong in the two groups of building materials and cloths and clothing.

Below are shown the index numbers of wholesale prices in the United States, by groups of commodities, as computed by the Bureau of Labor Statistics for the months named. The figures for the last named month are preliminary and subject to revision. The base used in computing these index numbers is the average for the calendar year 1913.

INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES.
(1913 equals 100.)

	1919. December.	1920. November.	1920. December.
Farm products	244	165	144
Food, etc.	234	195	172
Cloths and clothing	335	234	220
Fuel and lighting	181	258	236
Metals and metal products	169	170	157
Building materials	253	274	266
Chemicals and drugs	179	207	188
House-furnishing goods	303	362	[illegible]
Miscellaneous	229	220	[illegible]
All commodities	238	207	189

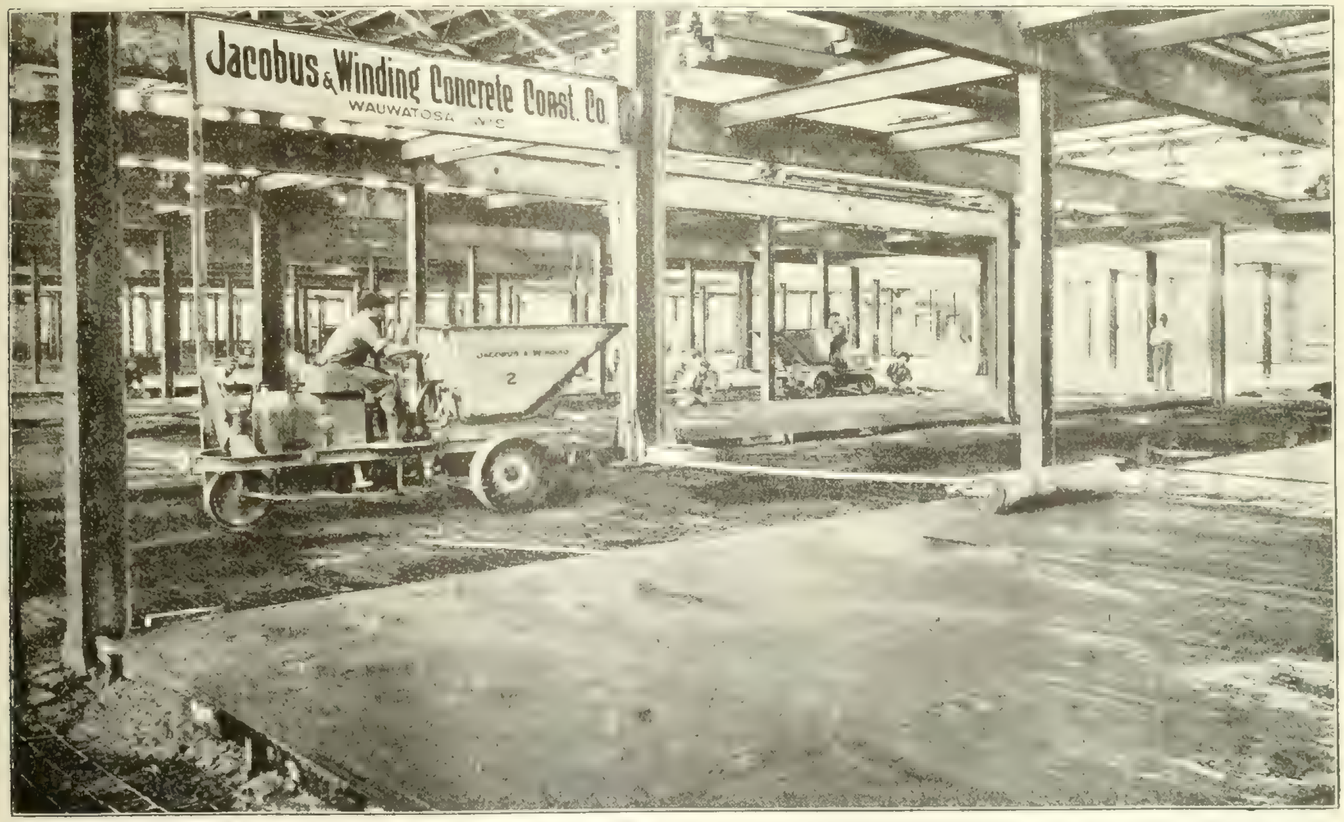
Comparing prices in December with those of a year ago, as measured by the changes in the index numbers, it is seen that foods have declined 26½ per cent, cloths and clothing 34⅓ per cent and farm products 41 per cent. In the groups of metal products and miscellaneous commodities, smaller declines have taken place. In the remaining groups the December price level was higher than that of a year ago, ranging from 5 per cent in the case of chemicals and drugs to over 30 per cent in the case of fuel and lighting. All commodities, taken in the aggregate, were over 20½ per cent cheaper than in December, 1919.

The Engineer and Industrial Waste*

By HERBERT HOOVER,

President, American [illegible] Council.

The Federation of Engineering Societies has been brought about solely that we might secure for public service the collective thought and influence of 100,000 to 200,000 of our professional engineers. This great body of men in administrative and technical service penetrate every industrial avenue and thus possesses a unique understanding of many of our intricate economic problems and an influence in their solution not equaled by any other part of the community. Wanting nothing from the public either individually or as a group, they are indeed in a position of disinterested service. This federation has initiated services to the public in many directions.



Delivering Mixed Aggregate With Tructractor in Concrete Floor Construction at Plant of A. O. Smith Corporation.

I propose to deal with only one measure of this service today. Your council has organized a preliminary survey of some of the weaknesses in our production system. This survey will attempt to visualize the nation as a single industrial organism and to examine its efficiency towards its only real object—the maximum production. In a general way this inquiry will bear upon the whole question of deficiency in production—industrial waste in a broad sense.

Measures of the Waste in Production. The waste in our production is measured by the unemployment, the lost time due to labor conflict, the losses in labor turnover, the failure to secure maximum production of the individual due either to misfit or lack of interest. Beyond this again is a wide area of waste in the poor co-ordination of great industries, the failures in transportation, coal and power supplies which re-echo daily to interrupt the steady operation of industry. There are again such other wastes due to lack of standardization, to speculation, to mismanagement, to inefficient national equipment and a hundred other causes. There is a certain proof of deficient production by comparisons of our intense results in 1918, when, with 20 per cent of our manpower withdrawn into the army, we yet produced 20 per cent more commodities than we are doing today. We are probably not producing more than 60 or 70 per cent of our capacity; that is, if we could synchronize all national effort to maximum production, we could produce [illegible] per cent more commodities and service. Our national machine is today doing worse than usual, as witness the 3,000,000 idle men walking our streets. One part of the human measure of this shortage in production is the lack of necessities or comforts to them and their families, and their anxieties as to the future.

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*Abstract of address delivered Feb. 14 before the American Engineering Council's Executive Board and Convention of Engineers at Syracuse, N. Y.

No one will ever suppose that it is ever possible to bring national productivity up to the full 100, but the whole basis of national progress, of an increased standard of living, of better human relations, indeed of the advancement of civilization, depends upon the continuous improvement in productivity. While we currently assume that great advances in living standards are brought about by new and basic invention, yet in fact even a greater field of increasing standards lies in the steady elimination of these wastes. The primary duty of organized society is to enlarge the lives and increase the standards of living of all the people—not of any special class whatever. We are therefore proposing to make a preliminary examination of the volume of waste in certain industries to determine the proportions that lie in each field of fault. And no engineering report is worth the paper it is written upon without constructive suggestions in remedy.

No Such Thing as National Over Production.—There is ofttimes a superficial dismissal of this subject of maximum production on the assumption that there are positive limits in production due to over-supply. Such assumption has no proper foundation in the broad view of industry as a whole. Too much economic thought on production has delimited its boundaries by the immediate volume of demand of a given commodity. There is no such thing as the nation over producing, if it produces the right commodities. The commodities or services produced by the whole nation are capable of absorption by the whole nation if they are of the right character. In other words, if we could attune the whole industrial machine to the highest pitch, agriculture as well as manufacture, an increasing production would mean a directly increasing standard of living. When 10 men or 100,000,000 men divide their united output, they can by doubling their output have twice the amount to divide. The problem in doubling output is to direct it to commodities or services that they can use. There is no limit to the increase of living standards except the limitations of human strain, scientific discovery, mechanical invention and natural resources.

It is true enough that any particular commodity or service can be over-produced, for each will reach a saturation point in demand when all the members of the community have been supplied. The absorption of increased productivity lies in the conversion of luxuries of today into necessities of tomorrow, and to spread these through the whole population by stimulation of habit and education. Wheat bread, railways, good roads, electricity, telephones, telegraphs, automobiles and movies were once luxuries. They are still luxuries to some parts of the population.

It is but a corollary that certain commodities can better be produced for exchange for commodities from outside our boundaries of more appropriate character to our needs. Today we have capacity for production of some commodities not only in excess of our home need, but even beyond export demand under present financial conditions. As a matter of practical remedy, we must either reorganize these financial relations or alternately abandon some part of this kind of production and turn our idle men to making things of which we are not yet fully supplied.

To put the matter in another way, there is no limit to consumption except the total capacity to produce, provided the surplus of productive power is constantly shifted to new articles from those that have reached the saturation point of demand. For instance, we have the productive capacity wasted today that would improve the housing conditions of our entire people to the level that perhaps only 50 per cent of them enjoy—and at the same time not entrench upon our established necessities. I am not suggesting that the forces of production can be shifted by imperial direction. The practical thing that can be done is to eliminate some of the wastes and misfits in our production, and depend upon the normal processes of business and human desires to absorb them.

Periods of Slack Production Cause of Greatest Waste.—The largest area of waste lies in the large periods of slack production and unemployment, due to the ebb and flow of economic tides between booms and slumps. The ideal would be steadily increasing production—an ideal of no likelihood of exact realization because of inability to ever gage the advance in growth consumption or the approach of saturation. On the other hand, there are certain possibilities of stabilization worth consideration. For instance, we can classify labor into that engaged in production and service from this equipment. Our studies of industries as a whole show that we usually expend our equipment just at the periods of maximum demand for their products instead of doing our plant expansion during periods of slack consumption. We thus make double demands on labor and we doubly increase unemployment in periods of reduced consumption. That is indeed one of the factors in our great unemployment today. Everyone knows that for our normal productivity, our transportation facilities are today inadequate. We know that we are insufficiently housed, insufficiently equipped in our public roads and our public utilities; that we need an entire revision of our power supply, that we need expansion of our waterways and yet armies of idle men are walking the streets. The reasons why this occurs are not far to seek, in that it is at times of high productivity that capital is most easily obtained. It is then that the necessity of increased equipment most impresses men's minds and it is the high hopes of these periods that lead then into the adventure of expansion. Nor is it possible to expect that all industry could be so stabilized as to do its capital construction in periods of depression in commodity demand. Nevertheless there are some industries that could, by co-operation of the government and co-operation amongst themselves, be led in this direction. More particularly does this apply to railways, telephones, telegraphs, power supplies and other public utilities, and to the expenditure upon our state, municipal and national public works.

Another variety of intermittent employment, and thus great waste, lies in certain industries now operating upon an unnecessarily wide seasonal fluctuation, as for instance the bituminous coal industry. This is today one of our worst functioning industries. These mines operate seasonally and erratically. They proceed from gluts to famines, from profiteering to bankruptcy. As already determined by our engineering bodies, the men who mine our coal find work only 70 per cent of their time. In other words, there are 30 per cent more equipment, 30 per cent more men, attached to this industry than are necessary if it were stabilized to continous operation. The mining engineers have already pointed out the directions in which remedy lies, through storage, through railway rate differentials and other remedies. Through constructive action, an army of men could be released from this industry of necessity to convert some luxury into a necessity of tomorrow. This is no plan to control prices or profits, although through it both the producer and consumer in coal could be placed upon a sounder basis than today. The interest of the consumer and producer is, however, even less important than relief from the intermittent employment and unemployment within this industry that today brings a train of indefinite human misery and some of our lowest standards of living.

Labor Trubles and Waste in Productivity.—The second largest area of waste in productivity is the eternal amount of labor friction, strikes and lockouts. The varied social and economic forces involved in this problem needs no repetition here. Fundamentally this is not alone a struggle for division of the results of production between capital and labor, but there is also a loss greater from strikes and lockouts in the element of purely human friction and loss outside the area of dispute on wages and hours. The growth of industry into large units has destroyed the old mutuality of interest between employe and employer. Our repetitive processes have tended to destroy the creative instinct and interest in employes; at times their efforts sink to low levels indeed. We will yet have to reorganize the whole employment relationship to find its solution. There is great promise in this field during the past two years, an dthe progress in this matter is one of the subjects under our inquiry.

Yet another variety of loss lies in the unnecessarily faulty distribution of our labor supply due to seasonal and to shifting demands. An adequate national employment service is indeed the first need to reduction of those wastes.

Standardization of Basic Products and Tools.—Probably the next largest fraction of waste in productivity lies in a too high degree of individualism in certain [illegible] and tools. In other words, a standardization of certain national utensils makes for economy in distribution, in operation and in repairs. The necessity of maximum production during the war opened a great vista of possibilities in this direction. Such standardization as car couplings, or wheels, and cars generally, represent real progress in this direction. These possibilities lie in a hundred directions. There are all sorts of cases from sizes of chains to the size of automobile wheels. Today dozens of different sizes are placed in the market by manufacturers and entail not only special equipment and skill to produce these many varieties, but also great stocks are required in distribution and losses are entailed due to lack of interchangeability. It is certain that there are a great many articles of every day use in which the manufacturer would indeed be glad to undertake some co-operation in standardization, from which the saving in national effort would be interpreted not into millions but into billions of dollars. This does not mean that we stamp the individuality out of manufacture or invention or decoration; it means basic sizes to common and every day things.

Another type of waste lies in our failure to advance our industrial equipment. The Super-Power Board will demonstrate the saving of 25,000,000 to 50,000,000 tons of coal annually by the electrification of our eastern power supply. The St. Lawrence Waterway Commission will demonstrate the saving of 5 to 10 ct. a bushel to the farmers of 15 states by unlocking the lakes to ocean-going vessels. Nor will this added efficiency to our national transport injure our present systems of canals and waterways, for we have ever found that the prosperity of an industry blesses them all.

Nor do we believe it is necessary to effect those things by the government. The spirit of co-operation that has been growing in our country during the last 30 years has already solved many things; it has standardized some things and is ripe for initiative toward co-operation of a widespread character. The leadership of our Federal government in bringing together the forces is needed. No greater field of service exists than the stimulation of such co-operation. The first step is sane analysis of weakness and sober proposal of remedy. If the facts can be established to an intelligent people such as ours, action is certain even if it be slow. Our engineers are in unique position for this service, and it is your obligation to carry it forward.

Effect of Varying the Number of Plies in Plywood

In making up plywood for a particular use the question frequently arises: Should three plies or more than three be used to obtain the required thickness? Some data from tests by the U. S. Forest Products Laboratory may be of assistance in answering this question.

An increase in the number of plies results in a decrease in the tensile and bending strength parallel to the grain of the faces and an increase in the corresponding strength at right angles to the grain of the faces.

If the same bending or tensile strength is desired in two directions, parallel and perpendicular to the grain of the faces, the greater the number of plies the more nearly the desired result is obtained. It must be borne in mind, however, that plywood with a large number of plies, while stronger at right angles to the grain of the faces, can not be so strong parallel to the grain of the faces as three-ply wood, and hence a three-ply panel is preferable where greater strength is desired in one direction than in the other.

Where great resistance to splitting is necessary, as in plywood that is fastened along the edges with screws and bolts and is subjected to forces through the fastenings, a large number of plies affords a better fastening.

It is common experience that a glued joint is more likely to fail when thick laminations are glued with the grain crossed than when thin laminations are glued. The same weakness exists in plywood when thick plies are glued together. When plywood is subject to moisture changes, stresses in the glued joint due to shrinkage are greater for the thick plies than for the thin plies. Hence in plywood constructed with many thin plies the glued joints will not be so likely to fail as in plywood constructed with a smaller number of thick plies.

Shrinkage of Portland Cement Mortars and Its Importance in Stucco Construction

A brief summary of the more important results of an investgation of the causes of shrinkage in Portland cement mortars and its relation to stucco finishes was given by Mr. J. C. Pearson of the U. S. Bureau of Standards in a paper presented Feb. 16 at the 17th annual convention of the American Concrete Institute. Precise measurements on nearly 200 mortar slabs were obtained during the investigation. The following abstract of Mr. Pearson's paper is taken from a preprint of the copyrighted proceedings of the Institute.

Details of Comparator.—In planning the laboratory work we were influenced by the impression that some of the so-called crazing and map cracking might be dependent upon the behavior of the coatings during the first 24 hours after their application. It, therefore, seemed desirable to devise some means of measuring the volume changes that might occur before and during the set of the various mixtures, as well as afterward. The ordinary strain gage was obviously unsuited for these earlier measurements, and the first efforts were accordingly devoted to the design and construction of a special comparator. This consists essentially of two microscopes mounted vertically 20 in. part on the ends of a horizontal steel shaft in such a manner that the carriage of the instrument spans the specimen under observation and allows the cross hairs to be focused on plugs embedded therein. When the setting has been made, the horizontal shaft is rotated through an angle of 45°, bringing the microscopes to bear upon a graduated invar steel meter bar, whereupon the distance between the marks is read directly. In the hands of an experienced operator, an accuracy of 0.005 mm. in setting and reading is readily attained with the apparatus.

In the beginning of our studies upon mortars we were under the impression that the shrinkage curves of the various mixtures under given conditions would be more or less characteristic of those mixtures. We anticipated, of course, that temperature and humidity would affect the results to some extent, but as it was not feasible to control both these factors without special installations of expensive equipment, we hoped that repetitions of the observations on similar specimens on different days would at least indicate the importance of these factors and show whether or not their control would be necessary.

Test Pieces Used.—In order to insure that the mortar specimens were as free from restraint as possible, simple box forms were selected. These were of such shape and size as to allow the mortar to be cast in 1x4x24 in. slabs. These forms were first well coated with shellac, and just previous to use were lined with heavily vaselined sheets of paper. In this manner they were made practically water-tight and offered a minimum of resistance to the free movements of the slabs.

Two pairs of glass plugs were set 50 cm. apart in the slabs immediately after the forms were filled, and the latter were then transferred to a position directly under the track upon which the comparator was mounted. Observations could thus be started within a few minutes after mixing and placing the mortar in the forms, and readings could be taken as frequeuntly as desired thereafter without disturbing the freshly molded specimens. Each observation consisted of independent readings on the two pairs of plugs, and it was found that the volume changes which occurred between successive observations, as determined by the two sets of readings, agreed within 0.01 mm., that is, within 0.002 of 1 per cent of the nominal distance between the plugs. This very close agreement was not always attained in the earlier readings, for there was evidence of slight irregular movements of the plugs before final set of the mortars occurred. These discrepancies were small, however, in comparison with the magnitude of the volume changes which generally occurred during this period.

A considerable portion of the work was confined to measurements on slabs of 1:3 Potomac River sand mortar, this being selected as a typical stucco mixture. In order to determine the behavior of these slabs as affected by uncontrolled factors, specimens were made to the same consistency with the same amount of water from time to time during the spring and summer of 1919. The range of results obtained from the initial measurements on these slabs is shown in Fig. 1. In this diagram the upper and lower curves define a zone of variations which may occur, particularly during the first 24 hours, under the conditions of the tests. The curves for the different slabs may lie anywhere in this zone, but as a rule they have the same general sweep as the limiting curves. The average typical behavior is represented by the smooth curve, which shows the characteristic initial expansion, followed by continuous shrinkage.

Difference in Manipulation.—These initial variations between exactly similar slabs were difficult to explain. They could not be satisfactorily accounted for by variations in temperature or humidity, although it was demonstrated that high humidity and low temperatures were favorable to initial expansion and low humidity and high temperatures were favorable to immediate or early contraction. After considerable experience it was found that differences in manipulation were the chief causes of initial variations in similar mortars, any excess of puddling or troweling in placing the mortar in the forms (which would, of course, tend to bring water to the surface) promoting rapid and pronounced expansion, whereas, any method of placing that avoided bringing an excess of moisture to the top usually resulted in early contraction.

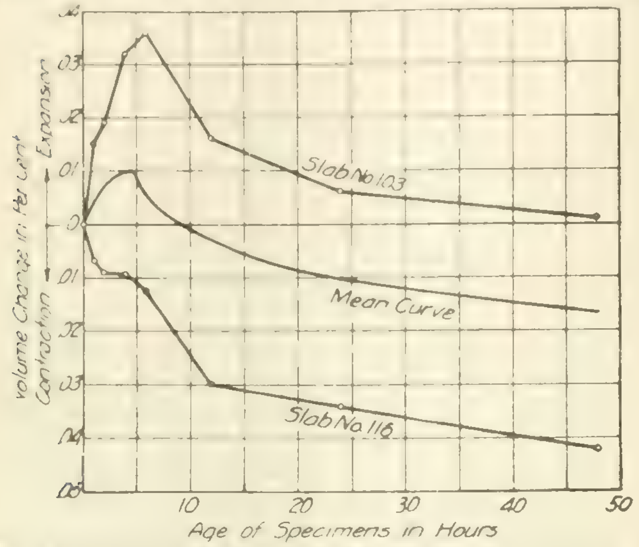

Fig. 1—Initial Volume Changes of 1:3 Potomac Sand Mortars in Water-Tight Forms. Normal Plastering Consistency, 15% Water.

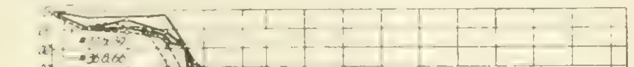

Fig. 2—Shrinkage Curves of Mortars Laid on Non-Absorptive Bases.

The results shown in Fig. 1 were obtained from mortars of the same proportions and mixed with the same percentage of water. The initial variations observed on a wide variety of mixtures were far more impressive. Such results were at the time incomprehensible—there seemed to be little or no relation between the magnitude of the volume changes and the proportions of the various mixtures. The amount of shrinkage observed in the case of certain mixtures was such that, if those mixtures were applied to walls as stucco coatings, and there behaved as they were doing in these tests, conspicuous and extensive cracking would have to occur within a few hours. The fact that this does not usually happen in actual practice led eventually to the conclusion that the method of conducting the tests involved extraneous factors and that a closer approach to practical conditions would be necessary.

For the first two or three hours while the mortars are still plastic, either moderate expansion or moderate contraction can occur, depending on conditions not controlled in these tests, but which we now believe can be controlled. Then at a time corresponding roughly to what we call initial set there is a tendency for pronounced contraction to occur, which generally shows up when the mortars are 8 to 10 hours old; that is, when the so-called final set is approaching. Finally from 12 to 24 hours there follows a period of comparative quiet in which slight shrinkage takes place. In other words, under the conditions of these tests large and apparently erratic volume changes may occur while the mortars are still plastic, and then, whatever be the total of these first changes, after the mortars become rigid gradual and steady shrinkage is observed. As will be shown in the following diagrams, these later changes seem largely independent of the changes that occur during the first 24 hours, even though the latter in some cases differ widely.

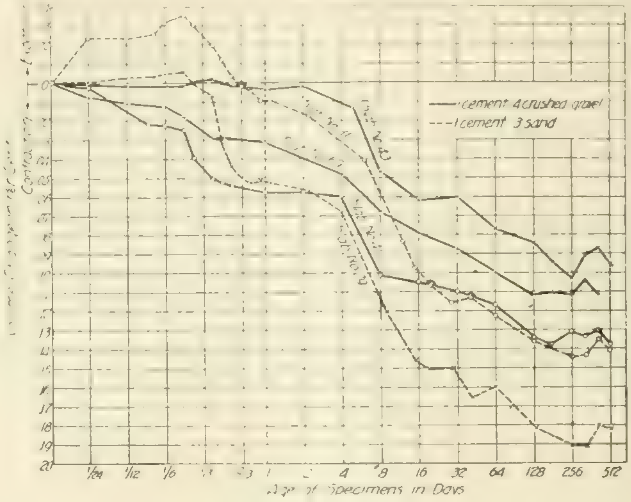

Fig. 3—Shrinkage Curves of Mortars Laid on Non-Absorptive Bases.

Shrinkage Curves for Mortars.—Figures 2 and 3 show various shrinkage curves for a number of stucco mortars. These curves are plotted to logarithmic scale in order to bring out the early erratic movements of the mortars, and at the same time to show the long continued shrinkage which persists for many months. Each diagram contains curves obtained from two or three identical specimens made on different dates. The divergence of the curves in each diagram depends very largely on the accidental volume changes which occurred during the first 24 hours, and it is evident that if the starting points of the curves were transferred to the 24-hour period (indicated by the dotted vertical lines) the curves for similar specimens would generally be in very fair agreement.

The study of these and similar curves led to a helpful point of view from which we regard the volume changes as occurring in two phases, the first phase covering the interval in which the mortars are plastic, the second when the mortars are rigid. The first phase is generally complete at about 12 hours, but since in practically all cases the changes from 12 to 24 hours are insignificant, the dividing line may advantageously be taken at 24 hours. It has been shown that the volume changes occurring in the second phase are apparently independent of those occurring in the first phase, and the problem can therefore be simplified by dividing it into two parts, each of which can be studied independently.

It was stated in a preceding paragraph that the volume changes observed in the first phase were in many instances too large to be considered representative of what actually happens in the case of applied stucco coatings. It was concluded that the chief difference between the conditions of the tests and the conditions encountered in practice was involved in the use of water-tight forms, which permitted loss of water only by evaporation, whereas in the application of stucco water is lost not only by evaporation, but also by the absorption of the base or the undercoats. This idea led to the substitution of plaster of paris slabs for the wooden bases of the forms. When these plaster bases are dry their absorption is high, and this absorption can be controlled by wetting them with measured quantities of water prior to filling the forms with mortar. Without going into too much detail, it was established that this absorption or "suction" as the plasterers call it, had a very great effect upon the time of set or stiffening of the mortars. If mortar was placed in a form with a dry base, set occurred almost before the plugs could be placed in position and the initial readings taken. Slight wetting of the plaster bases deferred this set until the early readings were taken, say from 15 to 20 minutes, and heavier wetting deferred the set still longer.

A considerable number of specimens of different proportions were made in forms of this type, some on dry bases, some on saturated bases, and some on damp or partly saturated bases. Finally on the advice of J. J. Earley a certain optimum condition of absorption in the plaster bases was selected as yielding a time of set for the mortars comparable with that which is recognized as best adapted to good results in stucco application. This arbitrary condition was such as to produce a stiff set of the mortars within 30 to 60 minutes after placing in the forms, but owing to the fact that its adoption as a criterion of a properly wetted base or undercoat did not come until rather late in the investigation, the observations made under this condition are comparatively few.

Initial Volume Changes.—A most important result was obtained in the experiments with these absorptive forms. Up to the point where setting of the mortars occurred within one hour the initial volume changes, which had been so marked in the earlier experiments, were very greatly reduced in practically all cases. Fig. 4 shows the extreme initial volume changes observed in the case of 1:3 mortars cast in forms with dry or partially wet bases. The very great majority of curves run close to the zero line, the maximum observed in the first 24 hours being less than .02 of 1 per cent. The effect of the absorption in reducing these initial movements may be best seen by comparing Fig. 4 with Fig. 1, all curves of which were obtained from 1:3 mortars mixed to normal plastering consistency.

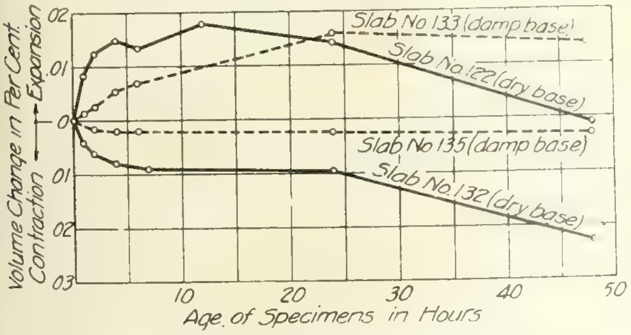

Fig. 4—Initial Volume Changes of 1:3 Mortars in Absorptive Forms, Normal Plastering Consistency.

Even more striking are the effects of the absorptive bases on a variety of mixtures, as shown by the curves in Fig. 5. In general it may be stated that when 1:3 or leaner mortars, that is, typical stucco mixtures, were cast in these absorptive forms, volume changes of more than 0.02 per cent during the first phase were the exception rather than the rule. It might be anticipated that the early behavior of mortars cast in forms having saturated plaster bases would be somewhat similar to that of the same mortars when cast in water-tight forms, since in both these cases appreciable loss of water could occur only from the exposed surface. It was noted, however, that early shrinkage did not develop when the saturated plaster bases were used. This is probably to be explained by a sort of reservoir action of the saturated bases, whereby the loss of moisture by evaporation from the exposed surface is partly replaced by the upward flow of moisture from the bases.

Volume Changes in Second Stage.—To pass on now to a consideration of the volume changes occurring in the second phase, that is, during the period beginning when the mortars are 24 hours old, Fig. 6 shows two zones defined by two pairs of curves, A, B, and C. D. The shrinkage curves obtained from 1:3 mortars laid on dry or partially wet absorptive bases, wherein the absorption was such as to produce stiff set of the mortars within about one hour after placing, lie within the zone AB. The shrinkage curves obtained from 1:3 mortars laid on saturated bases, wherein the time of set of the mortars was normal and similar to that obtained when water-tight forms were used, lie within the zone CD. These results indicate a very marked effect of the condition of wetness of the base on which the mortar is laid upon the total shrinkage that may occur during the second phase. It is seen that the effect of saturation is to prevent immediate shrinkage, but to permit a much greater total shrinkage than that which occurs when the absorption of the base is not wholly destroyed.

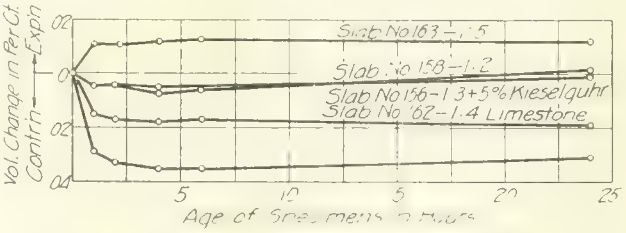

Fig. 5—Initial Volume Changes of Various Stucco Mortars in Absorptive Forms, Normal Plastering Consistency.

Experiments on other mixtures, while less numerous than those on the 1:3 mortars, confirm the foregoing results and indicate that control of the absorption or "suction" of the base is one of the most important factors governing the shrinkage that occurs after the mortars have set and hardened. Space is not available for showing the curves obtained from a number of stucco mixtures cast in absorptive forms under varying conditions of absorption, but in general they show the same relative variations that are shown by the two zones in Fig. 6. In general they show also that as the degree of wetting of the base is greater, the total second phase shrinkage of any mortar increases, and finally when the base is saturated, the total second phase shrinkage tends to exceed that which occurs when non-absorptive forms are used.

These studies indicate that the second phase volume changes of mortars under given conditions are more or less characteristic, and as a matter of interest some of the quantitative values obtained are given in Table I. The values are averages obtained from observations when the mortars were 64 days old, and are expressed in decimals of 1 per cent of the length of the specimens. The second column contains values for mortars cast in water-tight forms, the numbers in parentheses indicating the number of slabs from which the averages are derived. The third column gives corresponding shrinkage values obtained when the mortars were cast on dry or partly wet bases wherein the absorption was such as to produce a stiff set within about one hour after placing.

In connection with the values given in Table I, it should

TABLE I. SHRINKAGE VALUES OF VARIOUS MORTARS AT THE AGE OF 64 DAYS

Mortars mixed to normal plastering consistency and stored in the laboratory. Shrinkage expressed in decimals of 1 per cent.

	On non-absorptive bases.	On dry or damp absorptive bases.
Neat cement	0.21[illegible] (2)	
1 cement: 1 sand	0.1[illegible] (3)	
1 cement: 2 sand	0.110 (18)	0.067-0.108
1 cement: 3 sand ..	0.101 (6)	0.064-0.067
1 cement: 4 sand	0.094 (3)	0.059-0.081
1 cement: 5 sand .	0.086 (2)	0.060-0.080
1 cement: 6 sand	0.084 (2)	0.054-0.063
1 cement: 3 sand + 10% hydrated lime	0.114 (2)	
1 cement: 3 sand + 5% kieselguhr	0.110 (2)	0.077
0.75 cement: 0.25 hydrated lime: 3 sand	0.088 (2)	0.068
0.75 cement; 0.125 kieselguhr: [illegible] sand	0.119 (2)	....
0.75 cement: 0.25 hydrated lime: 4 sand..	0.078 (2)	..
1 cement: 4 limestone screenings	0.099 (3)	0.050-0.078
1 cement: 4 crushed gravel	0.067 (3)	0.058
1 cement: 6 limestone screenings	0.0[illegible] (2)	0.036
1 cement: 6 crushed gravel	0.050 (2)	0.024
1 blended cement (50c-50s): 3 sand.......	0.108 (2) .	0.055
1 cement: 3 coarse sand No. [illegible]	0.071 (3)	0.052-0.05[illegible]

be stated that the effects of temperature and humidity variations have been disregarded. Relatively these effects are not large, but probably sufficient to eliminate any special significance in the third decimal. The most important feature of the table is the reduction in shrinkage shown for the mortar laid on absorptive bases. The normal shrinkage is thus reduced on the average from 25 to 50 per cent for the majority of the stucco mixtures. In general the figures obtained for the different mixtures show a smaller range than those with which we are familiar. Thus the shrinkage of the mortars in the first group do not differ greatly in themselves, but if all or even a part of the initial shrinkage (occurring in the first 24 hours) were added to the values given in the table, the differences between the rich and lean mortars would be much more pronounced. Figs. 2 and 3 show clearly, however, that the movements occurring in the first phase are not characteristic of the mortars, but depend wholly upon the conditions of the tests, and unless all the conditions affecting the volume changes are known, such as the nature of the forms, the consistencies of the mortars, the conditions of exposure, etc., the figures obtained are of little value. Comparison of the shrinkage coefficients for the limestone, crushed gravel and sand mortars show also that the nature of the aggregate is an important factor, and further analysis of the data will undoubtedly offer an explanation for most of these differences.

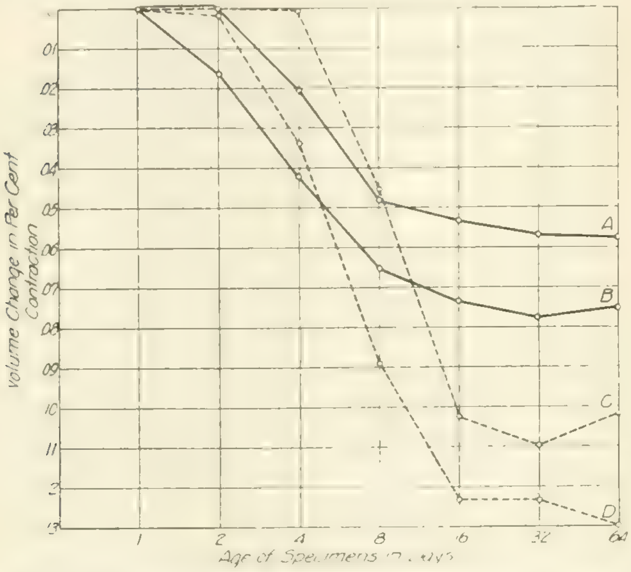

Fig. 6—A, B: Extreme Shrinkage Curves Obtained From 1:3 Mortars Laid in Absorptive Bases. C, D: Extreme Shrinkage Curves. Obtained From 1:3 Mortars Laid in Saturate Bases.

It is believed that these studies on the shrinkage of cement mortars help to explain the development of cracks, and the extent to which cracking occurs, in stucco finishes. Further, they also indicate the practical methods whereby shrinkage of stucco coats may be controlled, at least within certain limits, and its effects minimized. The earlier studies of mortars cast in water-tight forms, while having a limited application to stucco construction, have been of value in indicating the all important effect of moisture, and in differentiating between the shrinkage that may occur when the mortars are plastic and when they are rigid. These earlier studies also seem to indicate clearly the causes of the observed volumetric changes, although this matter has not been specifically referred to in this report.

The later studies of mortars laid on absorptive bases are of particular value in their relation to stucco. They have called attention to the importance of "suction" in a quantitative way which enables us to review the old notes on the stucco test panels and to understand in a general way why some cracked and crazed badly and why others are in excellent condition. It has been shown that the control of suction or absorption is the most vital factor in the control of shrinkage, both in the plastic and in the hardened mortars.

Building Exhibit in Belgium.—An international architectural and building exhibition will be held at Ghent from April 30 to June 28.

Arbitration Agreement of San Francisco Building Contractors and Workers

Industrial peace and industrial progress in San Francisco have been reasonably assured by a permanent arbitration agreement which has just been signed by the San Francisco Building Trades Council, representing the workmen, and the San Francisco Builders Exchange, repesenting the employers engaged in the building trades.

Under this agreement, which was brought about through the good offices of the industrial relations committee of the San Francisco Chamber of Commerce, the building contractors and the workmen have voluntarily set up a permanent Board of Arbitration and have bound themselves to submit to this Board of Arbitration for final decision all questions involving wages, hours and working conditions.

The members of the board of arbitration are the Most Reverend Edward J. Hanna, Archbishop of San Francisco; Max C. Sloss, former Justice of the Supreme Court of California, and George L. Bell, consultant in industrial relations and management.

All present and all future disputes in the building trades in San Francisco will be submitted to this arbitration board for adjudication, and its findings and judgment will be accepted as final by the parties to the agreement.

The arbitration board is non-partisan in character; each of the three members being held to represent, impartially, the interests of all parties involved—including the employer, the employee and the general public.

Under the agreement the arbitration board is given the widest latitude in the matter of initiating investigations into all conditions affecting the building trades, and is empowered to call for copies of contracts or agreements touching any phase of the building situation.

The hearings held by the board will be public, except as the board may decide otherwise, and the expenses incurred by the board in its work are to be borne equally by the parties to the agreement.

The agreement in full is as follows:

1. In the matter of arbitration between the Builders' Exchange and the Building Trades Council, we hereby accept the following three arbitrators, to-wit: Archbishop E. J. Hanna, Max C. Sloss, ex-associate justice of the Supreme Court of California, and George L. Bell, consultant in industrial relations and management.

2. It is understood that all three arbitrators to be deemed impartial arbitrators of all controversies, and under no circumstances is any one of them to be considered a representative on the Board of Arbitration of either of the contending parties.

3. It is agreed that this board shall sit as a continuing Board of Arbitration, to which shall be submitted all disputes as to hours, wages and working conditions in building trades where there are no disputes now, as well as in those where there are, when and as such disputes arise between the signatory parties, and that the decisions of the board shall be accepted as final and carried out by all parties. This step is taken in order to provide a permanent method of settling amicably, and in a reasonable manner, labor disputes in this city affecting the building trades, and with the hope that building operations henceforth may be put on a certain and stable basis—a result which will be of advantage to the workers, to the employers, and to the public.

4. It is agreed also that the Board of Arbitration may go into all questions concerning the general building situation, and call upon the signatory parties for information and copies of contracts or agreements concerning any phases which the board desires to investigate.

5. It is further agreed that the Board of Arbitration may incur such expense as it deems necessary for the employment of investigators and clerical assistance, and that the entire incurred expense by the board will be shared equally by the signatory parties.

6. It is understood that all hearings of the Board of Arbitration are to be conducted as public sessions, save, and except, such special hearings as in the judgment of the board should be held in executive session.

7. It is understood that the trades in which there are now disputes concerning hours, wages and working conditions, which disputes will be immediately submitted to the board, are as follows: Panters, glassworkers, varnishers and polishers, cement finishers, cement laborers, hodcarriers, tending plasterers, marble rubbers, and sawyers, marble finishers and polishers, marble masons, marble masons' helpers, hoisting and portable engineers, roofers, elevator constructors, elevator constructors' helpers, reinforced ironworkers, team and auto truck drivers, plasterers.

Instructions to Bridge and Building Inspectors

The standard instructions which follow have been in successful use by the Public Service Railway of New Jersey for a number of years, and are reprinted in full from an article by Howard H. George, Engineer Maintenance of Way, in the January 15 issue of Electric Railway Journal. As explained by Mr. George, copies of the instructions are given to each inspector their chief function being: 1. To afford complete and unquestioned instruction to men of inadequate previous experience. 2. To provide all inspectors with an authoritative source of reference for use whenever necessary. 3. To secure greater uniformity of practice through a reduction in the effect of the personal equation. 4. To save time and effort of the engineer or architect in charge in instructing his force and maintaining its efficiency of operation.

The instructions follow:

Information for Building and Bridge Inspectors.

Carefully study all plans, elevations or other drawings, and also all specifications, and see that the drawings are in conformity with each other and with the specifications.

Check all figures and dimensions on plans and details; check shop details as they are received to see that they do not conflict with scale drawings; also check all erection drawings in order to recommend some other procedure in an emergency should the necessity occur; also see that the specifications or special instructions agree.

Keep on the work in an accessible location special copies of all drawings, details and specifications, and carefully note on same any changes from the original plans, so as to keep a complete record of the work constructed.

Familiarize yourself with all local conditions or ordinances affecting the work and see that the same are rigidly adhered to.

Make the acquaintance of and keep in touch with the general contractor and all sub-contractors or other principals engaged on the work.

Establish diplomatic relations with adjoining property owners or residents, and see that all their rights are respected by the contractors.

Acquaint yourself with all traffic arrangements, whether regular or special, that may interfere in any way with the progress of the work.

Secure full information concerning the conditions of steel work being fabricated in the mills or shops; also of any other materials that may be under the course of construction, and ascertain the names of all contractors for same, date of orders and the probable date of shipment, and if necessary closely follow up same in order to secure proper delivery.

Should any incomplete work be fabricated that will need attention and correction at the site carefully look out for and see that all corrections are made before same is incorporated in the structure.

Material Shortage Can Be Prevented by Careful Checking.

Keep a record of the arrival of all materials. The contractor's record should be sufficient, if suitable, but should be carefully checked. Strive to anticipate any shortage of material and use all available facilities to hasten delivery; also arrange for the proper storage of same on the site.

Try to anticipate the need of detail drawings and notify the engineer or architect regarding same.

Study the progress of the work and try to determine whether it will be completed in the specified time, and, if in your opinion it will not be finished as specified, endeavor to secure such additions to the force and equipment as will secure completion within the allotted time.

See that the company's photographer is kept informed as to the progress of the work and that "progress photographs" are taken at least every ten days.

Keep a daily record of the force employed and the distribution of labor in such a manner as will clearly show the progress of the work, and also of all equipment in use at all times.

When "unit prices" are called for make a careful report of the cost of all material and labor which are included in same, separating the two items.

Never Interrupt Service Without Notifying Transportation Department.

Where necessary to interrupt regular car service see that sufficient notice is given the transportation department. Have full preparations made beforehand, so that such interruption shall be as short as possible and will occur at such a time as will least interfere with normal operation. Make a record of all delays to operation caused by such work; also see that proper signals are displayed for the protection of cars.

Keep in close touch with the office and designing engineer or architect and consult with them frequently as to the interpretation of all drawings or specifications.

Exercise a constant supervision of any sheath piling, underpinning, forms for concrete, or any other false work or temporary structure, and see that same are properly maintained and not removed until all masonry is set.

Keep careful account of any extra work in order to be able satisfactorily to explain and check all extras. Keep a daily record of the progress of the work in a separate field book for each job. Note the same, and, if any disputes arise, their settlement; also note variations, if any, from the plans or specifications. At the completion of the work see that all plans and specifications are corrected to agree with the work as constructed and make a final report showing costs where required.

Make careful preparations so that erection may proceed rapidly and that the period of any disturbance or delay may be reduced to a minimum.

See that all piping or sleeves for same are built through walls and that all other piping, conduits, drains or ducts called for in the plans are placed in the proper position and before any floors are laid or masonry constructed; also see that all chases or recesses are left in walls to receive piping, etc.

See that the substructures are placed and constructed in a manner that will conform to the steel plans.

Where piles are used in the foundation, the inspector shall see that they are properly driven and that they are cut off at the correct elevation.

Proper Shoring Will Prevent Trouble from Shifting Earth.

Carefully observe all surface and subsurface conditions and see that all excavations are shored or sheet-piled where necessary. If surface drains are necessary see that same are installed in advance of masonry. Be sure that all waterproofing is thoroughly jointed and lapped. Do not allow back filling against green walls unless same are braced; also see that all back-fill is well puddled.

See that the grades of pipes are uniform and properly supported, and that all plumbing work conforms with the requirements of the local authorities. See that all joints are carefully made and watertight.

Where concrete is required, see that the proper proportions are used and that the materials are up to the specifications. See that all reinforcement is placed in its proper location and held in such a manner that the placing of the concrete will not disturb it.

Where blasting is necessary see that the proper protection and warning is given to the public and to the cars operating in the danger zone, and that it is done at such a time as to cause the least interference with operation. The charges are to be so regulated and covered that no damage will result.

See that all machinery and boiler foundations are built true to detail. See that all stone or terra cotta work is perfect before same is placed in the work, and also see that all brick or other mason work is laid and anchored as specified. Be careful to see that all concrete work, whether reinforced or otherwise, is constructed as specified in all particulars.

See that all furring is in place and firmly secured before plaster work is started, and that sufficient time is given between coats, and that a proper backing is prepared for all tile and marble work.

See that all work is carefully aligned and accurately fitted. Closely watch the painting of all work.

Carefully examine all work before same in installed. See that all framing is accurately made and anchored and that all roughing and furring is built in. All finished work should be carefully inspected as to design, finish, etc. If necessary have a "mill inspection" made. Trim must not be applied until plastering is dry. See that all hardware is properly attached, including that to metal-covered work.

See that all flashings are carefully built in.

Be constantly on hand when work is in progress and note any damage to the metal, failure to conform to the specifications, or any special difficulty in assembling.

Make sure that each member of the structure is placed in its proper position. If match marks are used examine them with care. Endeavor to have the several members assembled in such order that no unsatisfactory makeshifts need be resorted to in getting some minor member in place.

Watch carefully the use of fillers, washers and threaded members to see that they are neither omitted nor misused.

Make certain that all parts of the structure are properly aligned and that the required camber exists before riveting. It is possible for a structure to be badly distorted although the rivet holes are well filled with bolts.

Watch the heating of rivets to insure against overheating and to make sure that scale is removed.

Examine and test carefully all field-driven rivets and have any that are loose or imperfect replaced.

Have cut out and replaced all rivets whether shop-driven or field-driven that may be loosened during erection and riveting.

Prevent injury to metal while removing rivets.

A careful and complete record in detail must be kept of the cost of all alteration or repair work wherever work of this nature occurs in any part of the construction; also a detail of the estimated cost to reproduce any and all structures that may be torn down, removed, or otherwise destroyed shall be kept, and a report in full sent to the engineer or architect immediately.

A careful check should be kept at all times of the amount of money being expended, and if there is any indication of a likelihood of the amount authorized being exceeded, notice thereof shall be given the engineer or architect immediately.

Difference Between Molds and Wood Destroyers

Not all fungi which live upon wood impair its strength, but conditions which promote the growth of molds, blue-stain fungus, and other non-injurious fungi are usually favorable to the growth of the wood destroyers, and these may be active on the same wood bearing the molds. Hence, the presence of mold on timbers intended for any structural purpose should cause them to be looked on with suspicion.

In the early stages of their growth the molds and the wood-destroying fungi sometimes have a very similar appearance, and there is no simple means known to the U. S. Forest Products Laboratory by which lumbermen and wood users can separate them at sight. The surface growth of molds is generally cottony or felty in appearance; the mycelium or fine mold threads are interwoven, never compacted into membranous sheets or strands. The mycelium of wood destroyers may be fluffy and glistening, but more usually are compacted into strands or fan-shaped patches.

The characteristic feature of mold growth on wood is the fact that the minute threads which enter the wood do not bore into the wood fibers or dissolve them away. They pass through the spaces between the fibers or enter them through the natural openings, called pits, which are found in the walls of certain cells. Starches, sugars, and other contents of wood cells constitute the food of the molds.

The wood destroying fungi are able to send their threads right through the wood fibers, breaking down the cell walls and utilizing portions of this decomposed material as food. This action very markedly weakens the wood, making it crumbly, stringy, or spongy—in other words, producing rot or decay. The presence of wood-destroying fungi in an advanced stage of growth is evidenced by fruiting bodies, commonly called mushrooms, toadstools, conchs, or brackets.

The principal economic loss caused by molds is through the staining or discoloration of the wood. No greater injury may be caused by the wood destroyers in their early stages; but their work will continue and finally result in the destruction of the wood if favorable moisture and temperature conditions prevail.

Saving Time for the Boss.—And incidentally for several others of the office force is effected by one business concern, noted for its efficiency, through a telephone signalling system. If a department head wants an office boy he moves his telephone hook slowly twice; if he wants a telegraph messenger he lifts the hook three times. The telephone operator executes the signalled instruction by sending the proper messenger, and the executive avoids any material interruption of his work and saves some valuable seconds.

Effect of Repeated Reversals of Stresses in Double Reinforced Concrete Beams

When the United States was called upon to greatly increase the size of its merchant marine, because of the war emergency, it became necessary to construct vessels in the shortest possible time and from various classes of materials. It was considered desirable to attempt to build some of these vessels from reinforced concrete. In order to build a concrete ocean-going vessel, it was necessary to subject the concrete to much higher stresses than are considered allowable in building operations; otherwise, the walls of the vessel would have been so thick that its carrying capacity would have been greatly reduced and its dead weight increased to a prohibitive figure.

In connection with the production of concrete ships, the U. S. Bureau of Standards was called upon by the Emergency Fleet Corporation to make a complete investigation of the effect of a large number of reversals of stresses in double reinforced concrete beams. The investigation covered a considerable period and the complete results have only recently been published for general circulation, as Technologic Paper No. 182 of the Bureau of Standards. Copies of the paper can be obtained of the Superintendent of Documents, Washington, D. C., at 15 ct. each.

The paper first describes the nature of the tests, which were designed to simulate to some extent the effect produced upon a ship by the action of the waves. These cause an alternate upward and downward deflection of the material of which the vessel is built; this action being known among nautical men as "hogging" or "sagging." The samples used for the test were concrete beams with reinforcement both in the top and bottom. The beams were 4x6 in. in cross section over-all and were tested with a span of 8 ft. The load was applied at two points, each 6 in. from the center of the span. It was applied at the rate of about 17 cycles per minute, each cycle including one upward and one downward application of the load. By means of a system of levers, the dead weight used for the load was multiplied 10 times at the beam. The loading mechanism was driven by an electric motor acting through a walking beam. Four beams were tested to failure and a fifth was loaded alternately through 2,000,000 cycles, after which the test was discontinued, although the beam did not appear to be approaching failure.

In the case of the four beams on which the tests were completed, failure was by tension in the steel and, generally, the beams showing the highest stresses withstood the smallest number of repetitions However, even the largest number of repetitions was so small that failure in the steel would not have been expected as the observed stresses were very low Other factors than the intensity of the tensile and compressive stresses evidently had a part in bringing about the early tension failure. All the tension failures in the reinforcing bars occurred at sections where large cracks extended entirely across the section of the beams. It is possible that in some cases the bending at these cracks was sufficient to make the bending of the bar an important factor in causing failure. This tendency was probably accentuated by the slipping of bars at the ends which occurred with one of the beams and was accompanied by the opening up of wide cracks. The presence of gage holes in the bars apparently had some influence in hastening tension failure, but the nature of this influence was not very distinct. The quality of steel used for most of the reinforcement was poor and this would contribute to bringing about an early failure, although it does not alone account for the small number of repetitious of stress which were withstood in these tests.

After 7,000 cycles of load, the slip at the end of the bar in one of the beams was less than 1/1,000 in.; that is, less than the amount which has been taken as the criterion of safe conditions based on tests of the bond resistance between concrete and steel; yet after 400,000 cycles of load, the amount of slip had increased so much that failure by slipping of the bars seemed imminent. In all probability, had not tension failure intervened after an unexpectedly small number of repetitions of load, bond failure of this specimen would have occurred.

Eliminating the Irresponsible Contractor*

By WILLIAM B. JOYCE,
President, of the National Surety Co.

Undoubtedly one of the most important public duties of reputable contractors and surety companies in 1921 will be to conduct an increasingly energetic campaign against irresponsible contractors.

Unfinished contracts of bankrupt contractors cost the surety companies large sums annually. Good business diverted from reputable contractors by irresponsible ones amounts every year to very many millions.

But the heaviest loser is the taxpayer. When will the American taxpayer weary of continually paying large sums for inferior and long-delayed work by irresponsible contractors—often, indeed, paying heavily for work which is never wholly completed?

In our 1921 campaign against irresponsible contractors, we should make the taxpayer our intelligent and active ally. And we can easily make an ally of him if we will merely take the trouble to keep him constantly informed through his local newspaper regarding what public contracts are to be awarded, what pratical problems and difficulties these contracts involve; and how much these problems and difficulties may cost him if inefficiently and ignorantly handled.

Indeed, an important piece of advice that I might give is to urge your contractor organizations in your home cities to cultivate the editors of the local newspapers and to form the business habit of giving these editors complete information in advance regarding important public contracts which are about to be let. This will not only make the taxpayers intelligent and alert, but it will keep the public authorities themselves from awarding the contracts to irresponsible persons. Neither the contractors nor the surety companies have ever practiced a hundredth part of the public education which they should practice. Yet public education of this kind is obviously the most effective way to drive irresponsible contractors out of business.

Submitting Bids and Awarding Contracts.—The problem "Should Unlimited Competition Be Continued on Public Works" should be divided into two parts.

In the mere submitting of bids, wide competition is only fair, since it merely permits everyone to submit a statement of his qualifications so that the authorities may consider them.

In awarding the contract, however, the public authorities should invariably limit consideration to such contractors as can prove beyond doubt their ability to perform the work. Any other course is to imperil taxpayers' money and to fail in efficient conduct of public office.

What Contractor Must Have.—Consideration should be given only to contractors who possess adequate experience, adequate financial resources, adequate plant and equipment, and have not too much other work on hand.

You reputable contractors, if you have not already done so, should look up the ordinances of your home cities and the laws of your home state to make sure that all public officials, empowered to award contracts, are legally able to make these awards on this basis.

Local contractor organizations should also prepare lists of contractors whose experience, resources and equipment make them eligible to perform different public contracts and should furnish these lists to all public officials empowered to award contracts. If this is done in good faith as a public duty it will undoubtedly, in some cases at least, produce an intelligent reaction.

Local contractor organizations, in my judgment, can fully control the local situations if they are intelligently aggressive. They are entirely able to drive irresponsible contractors out of business and cause public contracts to be awarded only to competent ones.

Old-Time Methods Taboo.—I understand that the pernicious old-time methods of "closed specifications," and of calling for bids at a certain hour, etc., have been discounted in most communities because they promoted graft and favoritism; but in cities and states where ordinances and laws require the allotment of contracts to "the lowest bidder" irrespective of ability, local contractor organizations should have such ordinances and laws amended at once.

The irresponsible contractor throws our entire American system of public construction into disrepute and chaos. Even when irresponsible contractors put up certified checks to guarantee their bids they have been able to escape forfeiture of the check by claiming in a law court that they have made an error in assembling their estimates. Banks also have been known to furnish certified checks to irresponsible contractors who had not a cent on deposit; and to finance them later by taking assignments of their contracts.

Surely underwriters are occasionally deceived by irresponsible contractors. Indeed, the chief reason that so many irresponsible contractors escape prison is that neither surety companies, public officials nor anyone else has time or patience to prosecute them unless a substantial loss of money is involved.

Require a Bid Bond.—One of the best ways to eliminate the irresponsible bidder on public work may be to require a bid bond so worded as to remain in force as a contract bond in the case the bidder is successful. In this manner, no prudent surety company would write any bond for any bidder unless all circumstances, after thorough investigation, tended to show that the bidder had the necessary quick assets, plant and experience to carry on the work, with not too much work on hand nor too many other liabilities; that his reputation and banking and material references were all right; and that his record generally is above reproach in every place he has done work.

In closing, I wish to emphasize the need of greater exactness—indeed, in some cases, I regret to say, of greater honesty—in the financial statements which contractors make to surety companies in seeking surety bonds. In some states, the statutes protect the surety companies in this respect. The surety companies hope ultimately to obtain full protection against misleading financial statements in all states. The co-operation of reputable contractors, individually and through their organizations, is asked in this important matter.

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*From an address Jan. 26 before the 2nd Annual Convention of the Associated General Contractors of America, New Orleans, La.

Electric Outfit for Cleaning Stone and Removing Form Marks From Concrete

The accompanying illustration shows a portable electric outfit in operation on the Hanna Bldg. in Cleveland, O., cleaning stone by means of a wire scratch brush. Four of these machines were used on this building, and it is stated that each machine cleaned an average of 520 sq. ft per day. The contractor estimates that his machines are doing the work which would normally require 16 men. The stone was thoroughly cleaned, giving it a uniform color by means of this equipment. The same equipment is used for cleaning form marks on concrete immediately after the forms are removed, as well as removing rust from fences and grilles, etc., before painting. This equipment has a ½ HP. motor for 110 or 220 volt D. C. or 110 or 220 volt single phase A. C., and a 6-ft. by ½-in. flexible shaft. It has three speeds—900, 1,800 and 3,600. It's shipping weight is 175 lb. The outfit is manufactured by the R. G. Haskins Co., 27 S. Desplaines St., Chicago, Ill.

Fabricating Shops' Contracts in January.—The records of the Bridge Builders' & Structural Society, from reports collected by its secretary, show that during the month of January, 1921, 32,000 tons of fabricated structural steel were contracted for throughout the United States, equivalent to 18 per cent of the entire capacity of the bridge and structural shops of the country.

Crayons Better Than Water Colors for Tinting Charts

How crayon colors, spread with gasoline, produce better results in the hands of a novice and quicker results in the hands of an expert than do the more usual water colors is described in the February number of "Reclamation Record" in an article by Julian Hinds, Engineer, U. S. Reclamation Service, entitled "Use of Crayons for Tinting Charts and Diagrams." The article follows in full.

The application of color to progress charts and maps and diagrams for reports is a part of the work of every engineering office. If properly handled, water color is perhaps the best material to be used for this purpose, but colored crayons can be used with greater ease and with very good effect. Few draftsmen are able, without considerable practice, to do water-color work neatly, whereas crayon color may be applied by almost anyone.

To secure the best effect, the crayon should be applied lightly to the paper and spread with gasoline. The gasoline may be applied with strips cut from an ordinary blotter or with a fairly stiff color brush. The blotting paper may be rolled or folded, if desired, to give greater stiffness. Absorbent cotton twisted around a sharpened stick also makes an excellent spreader. For small or narrow areas a soft splinter, or a match stick, sharpened to a blunt point may be used. For large areas an artist's stub will be found convenient. The amount of gasoline used will depend largely upon the kind of paper upon which the color is being spread and upon the skill of the draftsman. Some men prefer to flow the gasoline on rather freely, rubbing the color very lightly; others prefer to use only enough gasoline to moisten the spreader. In the latter case, more rubbing will be required, but a more uniform and even distribution of the pigment will be obtained.

Crayon colors have a distinct advantage in that they can be applied to tracing cloth. For this purpose a blotting paper or cotton spreader should be used with a minimum amount of gasoline. If the gasoline is flowed on too freely the color may be entirely removed. With a little practice excellent results can be obtained.

In applying the color to the paper, it is important that the crayon be rubbed in lightly. If pressure is used the pigments are rubbed into the paper and will not spread readily. Deep tones should be obtained by continued light rubbing. The colors are much stronger after spreading and care should be used not to apply too much pigment.

After the application of the gasoline, the color should be dead flat, uniform, and perfectly transparent. Color applied in this way does not readily rub off, but unless the paper is very porous may be removed with a soft rubber eraser.

An inexperienced man will get much more artistic results with gasoline and crayon than with water color, and an experienced man will get good results with a much smaller expenditure of time and patience. For small intermittent jobs, crayons possess the advantage of being always ready and requiring no paraphernalia. Also, shades applied at different times are easily matched. Wax crayons probably give best results, but any kind of colored pencil or "lead" pencil may be used.

Civil Engineers to Award Annual Transportation Prize.—At its annual meeting held in the Engineering Societies Building, New York City, Jan. 19, the American Society of Civil Engineers, through its Board of Direction, accepted the offer of Engineering News-Record to establish an "Arthur M. Wellington Prize," to be awarded annually for the best paper presented before the society on any phase of the science and art of transportation, whether by land, water or air. The prize is a memorial in honor of the formed editor of Engineering News and author of the well-known book entitled "The Economic Theory of Railway Location." A fund of $2,000 has been provided, the annual income from which will constitute the material element of the prize. The donor has made the following two reservations regarding the award: First, that it may be made only for papers on a transportation subject; second, that it be not restricted to members of the American Society of Civil Engineers. The latter suggestion is offered because the great advances in transportation in the future may be on water or in the air, specialties in which civil engineers do not normally engage.

Building Construction in 23 Representative Cities

American cities are being built out of balance, providing workshops, but no places for the workers to live, declared John Ihlder, manager of the Civic Development Department of the Chamber of Commerce of the United States before the conference on the construction industry, held last week by the Philadelphia Chamber of Commerce. Mr. Ihlder based his statement on figures gathered from twenty-three representative cities of the country, which showed a decided falling off in the number of homes erected during the last several years and a gain in the number of factories put up.

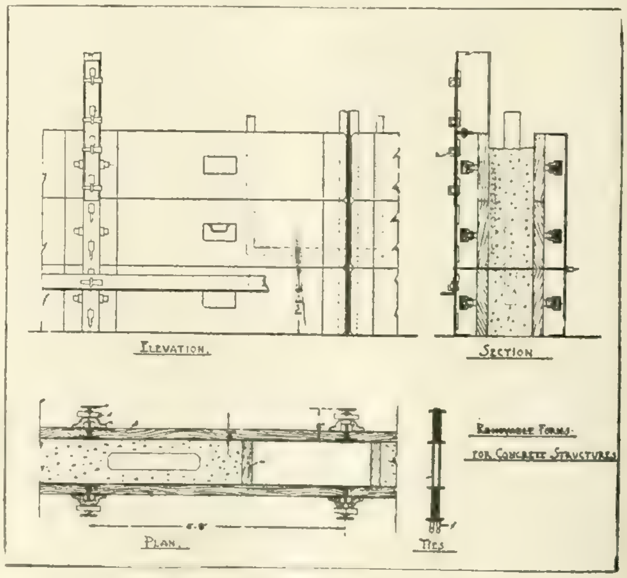
The twenty-three cities in which Mr. Ihlder made a survey on the housing situation have a combined population of 7,921,690, and each of them has a population of 100,000 or more. In these cities the total number of dwelling permits reached a peak of 31,333 in 1916. Then construction fell rapidly to 10,788 permits in 1918, rose to 26,041 in 1919, and fell again to 14,291 in 1920.

An interesting feature was the stability of small houses as compared with multi-family dwellings; apartment and tenement houses. While the small houses in 1919 numbered 25,029, within a thousand of the number in 1914 and less than 4,000 below the peak in 1916, multi-family dwellings dropped from 2,040 in 1916 to 2,000 in 1914 to 483 in 1918 and rose again only to 1,012 in 1919. In 1920 of the total number of dwelling permits 13,847 were for small houses and only 444 for multi-family dwellings.

Permits for business and industrial building showed greater steadiness. These increased from 1,832 in 1914 to 2,206 in 1916, suffered only a comparatively slight check in 1917 and 1918, in the latter year reaching bottom at 1,306, then quickly rebounded in 1919 to 2,286, a figure above the 1916 peak, and in 1920 actually made a new record of 2,414.

I-Beam and Plank Concrete Form System

A recently patented system of forms for concrete structures is illustrated. The forms consist of 6-in by 3-in. steel I-beams, weighing 6 lb. per foot, and 2 in. plank lined with sheet metal. Clamps pass through openings in the web of the beam and press the plates in place by means of wedges. Tie rods made from ¼-in. U-bolts pass through holes in the beams. The posts are spliced by the use of plate and keys with wedges fastened in the slot in flanges of the I-beams. In some cases, if the posts are longer, the splicing also can be done with bolts pressing through the bent edge of the beams. The liners for rigidity are fastened to the post by means of keys and wedges. Alexis Zakharoff, 1316 E. 52nd St., Chicago, Ill., is the Patentee.



Plan, Elevation and Section of Form.

An Architects View of Building Contracts*

By LAWRENCE MAURAN.
Past President, American Institute of Architects.

There are some architects today who advise their clients that a general contractor is an unnecessary "middleman," and they undertake for the owner those functions which they conceive are all that the general contractor has to offer in exchange for a very substantial profit. My own belief is that these men are wrong—that their viewpoint is narrow and warped, possibly by unfortunate experiences with individual contractors, whose aim was obviously the extraction of the maximum profit while the service rendered was that of a broker. I believe that every cobbler should stick to his last, and so I can no more see the advantage to the owner of such a method than I can see the propriety, in these days of highly specialized effort under competent guidance, of the course of an architect I know who prides himself on doing personally every branch of the work, foundations, design, structural engineering, plumbing and all the engineering of every description. The result is not happy, as a whole, nor, I understand from competent critics, in many of its parts.

My views are well known to many of you and they need but little elaboration. It was over 20 years ago that an emergency—the desirability of wrecking a burned building, preparing the steel requirements for fabrication, etc., in advance of completing the drawings—led me to take up the lantern of Diogenes and search for that common product of today, but which at that time was supposed to be non-existent, a contractor who would act for us in a purely professional capacity. I may say that the somewhat incredulous client never had cause for anything but satisfaction, and that justification of our judgment as to the right relationship between you, the owner, and ourselves, has led us to follow the same procedure many years and many times before the cost-plus contract became an everyday affair and one which I regret to say is today not altogether in good order.

Why Many Owners Fear Cost-Plus Contracts.—The reason why many owners say when cost-plus is suggested, "no thank you, not for mine," is not far to seek. First of all, war exigencies were in many instances transformed into war scandals by a press which knows as little of the magnificent accomplishments which such a method alone permitted, as does the average client of the real nature of his building problem. Again the method suffered at the hands of some of your calling and some of my own profession, who lost all sense of proportion in the new freedom the method permitted. Now when we were confronted by the market conditions of a year ago, coupled with sheer inability to secure figures in competition which represented anything but excessive insurance against loss to the successful bidder, we put forward the solution which carries with it no claim to novelty except that it is based on the profound belief that an expert director of building operations renders a highly professional service, and that the highest type of such a co-worker seeks above all to justify the confidence reposed in him. And so it only remained to eradicate the one unpalatable feature to the owner—the lurking fear that in such a skyrocket market the contractor could but rejoice as his percentage formed part of the pyrotechnics. We frankly advocated the "cost-plus a fixed fee" for the contractor, and, that we, too, might escape the thought even of profiting by the owner's misfortune, we offered to perform our entire service for a fixed fee.

Fixed Fee as a Measure of Equity.—In all of our work for over a year we have pursued the method thus briefly outlined and there are several correlative features of interest related in an article I contributed to the November number of the Journal of the American Institute of Architects under the title "The fixed fee as a measure of equity."

Out of the very considerable number of competent, honest—and if I may venture to say so—altruistic general contractors we select the one whose experience on the particular class of work commends him, provided his office conditions guarantee the essential personal service, or, all things being equal, suggest two or more for the owner's selection, and then agree in conference on a fixed fee in lieu of overhead and profit. The element of gain from other sources being eliminated, the contractor's service at once becomes semi-professional and a new opportunity is presented for added prestige—added opportunities for just this selection through the character of the service he is able to render and the proofs he can offer in the final accounting of his faithful stewardship.

With the banishment of the old order of expensive, unremunerative bidding in competition it appears to me that a new era is approaching, an era of friendly conference for the benefit of the owner and the public—altruism again—between the best minds in construction on an equal footing, the expert builder and the expert architect, and the rendering by both for a fee that ensures remuneration and satisfaction to all concerned of a truly professional service.

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*From an address presented Jan. 25 at the Second National Conference of the Associated General Contractors of America.

L. W. Wallace Elected Secretary of American Engineering Council

At the meeting of the executive board of the American Engineering Council of the Federated American Engineering Societies at Syracuse, N. Y., on Feb. 14, Lawrence Wilkerson Wallace was elected secretary of the council, succeeding L. P. Alford of New York, who has been acting secretary since the formation of the council in Washington on Nov. 19, 1920. Mr. Wallace has been one of the most active figures in the council and from the time it was organized has been its treasurer. As vice-chairman of the council Mr. Wallace has been directing the work of the committee on elimination of waste in industry, one of the principal committee of the council whose scope following the Syracuse meeting will be greatly broadened.

Mr. Wallace was born in Austin, Texas, Aug. 5, 1881. He was graduated from the Agricultural and Mechanical College of Texas in 1903 with the degree of B. S. in mechanical engineering. In 1912 he received the degree of M. E. from Purdue University. From 1903 to 1906 he served a special apprenticeship with the Sant Fe Ry. Co. and was a member of the Purdue faculty during 1906-07 becaming head of the department of railway and industrial management. During this period Mr. Wallace conducted researches and did consulting work in railway mechanical engineering and factory management. For several years he investigated fire losses from locomotive sparks and gave expert testimony in many fire cases.

Mr. Wallace is well-known as an author of technical works. His volume on "Car Design" is used as a textbook as well as generally by designers. He also has written special instruction books for railway educational departments and papers on engineering and management topics before railway and management societies.

Mr. Wallace brings to the secretaryship of the council the experience of a manufacturing executive. He was formerly assistant general manager in charge of Production of the Diamond Chain & Manufacturing Co. of Indianapolis. More recently he has been director of the Red Cross Institute for the Blind in Baltimore, which provided vocational training to the blinded men of the military forces.

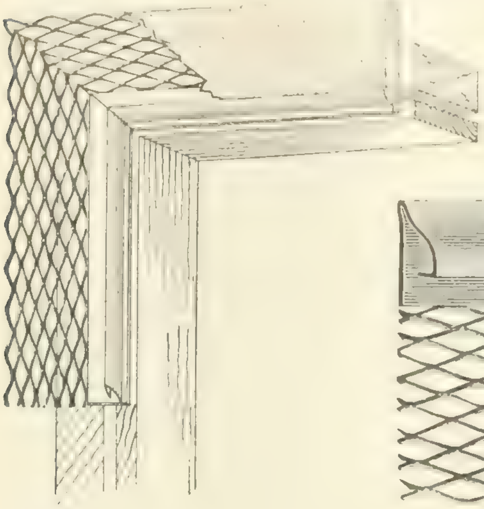
Mr. Wallace is a member of the American Society of Mechanical Engineers and the vice-chairman of the society's management section. He is now serving his third term as president of the Society of Industrial Engineers and is a past president of the Indiana Engineering Society. Mr. Wallace is a member of the International Railway Fuel Association, Western Railway Club, Master Car Builders Association, Academy of Political and Social Science, and Western Efficiency Societies. He is prominent in Masonry, and is a past grand lecturer of the Grand Lodge of Indiana.

Mr. Wallace's social and commercial activities embrace a wide range. His work in New York as vice-chairman of the committee on elimination of waste in industry has been instrumental in bringing national attention to the purposes of the council.

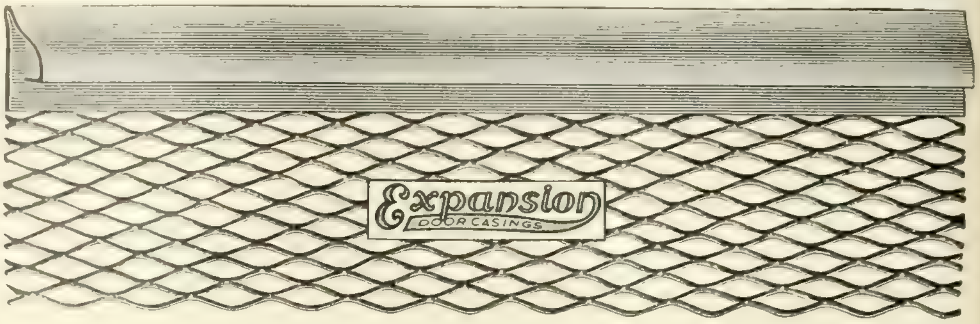
Mr. Wallace, now at the temporary headquarters of the council in the Engineering Societies Bldg., New York City, will soon transfer his activities to Washington, where the council has established permanent national headquarters in the McLachlen Building. The Employment Service Bureau will be continued in New York where Walter V. Brown is in charge.

New Expansion Door Casing Has Expanded Metal Wings

An expansion door casing having expanded metal wings has just been brought out by the Milwaukee Corrugating Co., Milwaukee, Wis. The wings are integral with the casing. They provide a tie with the adjoining wall and reinforce the plastering at its weakest point in such construction, thus avoiding cracks. The casings serve as grounds for the plaster and are used around doors and windows. They displace wood trim and serve to make the work fire-proof and more sanitary. The casings are flush with the plastering and leave no projections on which dust, etc., may settle. They may be carried down to the floor, eliminating plinth and grounds. The casings may be had in O. G. or ¼ round forms, or in any simple modification of same. They are made, unless otherwise ordered, for ⅞-in. grounds and are furnished in 6-7-8-9-10 and 12 ft. lengths. They are made from prime Tite-coated galvanized sheets and are crated approximately 500 ft. to the crate.



Application of Door Casing.



Expansion Door Casing with Expanded Metal Wings.

Inducing Designers to Use Standard Parts

An interesting means to secure a practical maximum use of standard parts in machine and fixture design is recounted by Mr. L. F. Libgotte in Industrial Management for January 1 in an article entitled "The Reorganization of a French Drafting Department." After telling in some detail how efficiency was increased by consolidating separate drafting offices in a large establishment, reducing supervision, developing improved methods, and providing improved equipment, Mr. Libgotte takes up the use of templets of standard parts, and tells how this use was stimulated as follows:

As soon as anything is to be drawn, whether a machine, a fixture or a tool, the men are instructed to employ the templet of a standard part. Those templets are made of zinc, and when too big, are made to a scale at which the complete drawing shall be done.

The templets are classified in square envelopes without a lap, on which is indicated the pattern or stock number of the part, its name and the number of the envelope. The principal characteristics are also indicated and if the part has details as would for instance be the case in a standard vise the stock numbers of the details are also given. A piece of blueprint is stuck on the envelope to give a sketch of the part referred to and when it is too complicated to be seen on a small scale, a drawing is included in the envelope.

The templets bear small notches which correspond to the axes of the piece and facilitate the location on the paper. The man has then just to draw round that templet and in the event of an intricate piece it saves an enormous amount of time.

The templets which are in great demand such as bolts, screws, gears are made in three or four duplicates so that there is no waiting necessary.

All standard parts, as soon as agreed upon must have their templet and envelope made and entered into the record books.

I quite realize that all this means a great deal of work, nevertheless it will be found in all cases very profitable, if it is worked with the following system of bonus for the draftsmen. For in order to insure plenty of good will toward the use of the standard parts and their templets (for it's just as easy in a design to employ standard parts as others) it is good to make an inducement to the men by giving them a bonus of so much per each part employed in a new design; which bonus would vary according to the importance of the work.

It is quite easy to understand that a man who has designed a punch press and who has employed, for instance, a standard shaft or flywheel has deserved better than the one who shall have employed merely 6 or 7 standard bolts and who has made an entirely new shaft and flywheel.

House Shortage in America.—Estimates submitted last month to the National Council of the U. S. Chamber of Commerce place the shortage of houses in America at more than 1,250,000. It also is estimated that the housing shortage has reached such a point that 4,000,000 people are inadequately provided for.

Personals

Edward Mahnke has been re-elected building commissioner of the city of Waterloo, Ia.

C. J. Rogers, for the past 3 years chief assistant to the county engineer of Jefferson County, Alabama, has been appointed county engineer.

R. Hugger, E. S. Hugger and Jas. A. Jehle have taken out incorporation papers for the Hugger Brothers Construction Co., Montgomery, Ala.

Sidney E. Deane has resigned as county surveyor of Fayetteville, Ark., to accept a position with the W. P. Coal Co. of Wyoming at Rock Springs, Wyo.

Elmer J. Clark has been appointed assistant superintendent of public works in charge of the middle division of the New York State Barge Canal with headquarters at Syracuse, N. Y.

V. J. Cramer, for 3½ years with the Wayne Oil Tank & Pump Co., Fort Wayne, Ind., has become associated with the Moellering Construction Co., building contractors, Fort Wayne, as general sales manager. He succeeds Harry J. Rowell, who has been with the Moellering Co. for 15 years and who is now going into business for himself.

R. C. Marshall, Jr., chief of the construction division of the War Department during the war, has been nominated for brigadier general in the Officers Reserve Corps by President Wilson. Gen. Marshall held that rank in the national army during the war, but resigned from the military establishment after the armistice to become general manager of the Associated General Contractors of America.

Col. Francis A. Pope, engineer in charge of the U. S. engineering office at Duluth, Minn., has been transferred to the Philippine Islands. There he will have charge of defensive works and be in command of the Fourteenth Engineers, United States Army. Maj. Edwin H. Marks, at present connected with the office of the chief engineers at Washington, will succeed Col. Pope at Duluth. Maj. Marks was formerly stationed at Detroit.

Industrial Notes

George J. Blanton, who for the past four years has been connected with the engineering sales department of the Chain Belt Co., Milwaukee, Wis., has been made New York district manager. He will leave immediately to take charge of the company's offices at 50 Church St., New York.

The Conveyors Corporation of America, formerly the American Steam Conveyor Corporation, Chicago and New York, announces that S. D. Inman has been placed in charge of the engineering and design of their American trolley carrier, monorail conveying equipment for handling coal, ashes, sand, gravel and like bulky materials from railway car to pile, bin or bunker.

The Lakewood Engineering Co., Cleveland, O., announces that the complete line of steel forms for road, sidewalk, curb, gutter, walls, culvert and post construction, manufactured by the Hotchkiss Metal Products Co., Binghampton, N. Y., will now be offered as a part of the Lakewood line of complete road and general construction equipment. Plans are under way for enlarging the Hotchkiss plant to increase the already large facilities for form production. The Lakewood-Hotchkiss complete line of steel forms will be carried in stock in the Lakewood warehouses in 18 cities. A similar arrangement has been made with the Burton Engineering & Machinery Co. of Cincinnati, manufacturers of gasoline locomotives.

Roads and Streets Monthly Issue

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Criticism of California Concrete Roads

The state highways of California have so long been regarded as models of excellence that it will surprise many engineers to read the severe criticism of them in a joint report of the engineers employed by two California automobile clubs. A six months' investigation of these roads has been conducted under the direction of J. B. Lippincott, Walter C. Howe, E. J. Brunnier and Prof. Charles Derleth, Jr., assisted by 10 other civil engineers.

Most of the California state roads are of concrete 4 in. thick, and many of them are paved only 15 ft. wide. The main criticism made by the investigators is that the concrete is too thin and too narrow. As to this criticism it is only fair to say that engineers who are acquainted with California roads and their history will differ. The editor has visited California every year since the State Highway Commission has been in existence, and each time has taken pains to inspect a large part of the road mileage built by the state. He has just finished such an inspection, and it is his opinion that the building of narrow 4-in. concrete pavements was a judicious expenditure of the state's highway funds.

It should be remembered that most of the mileage of California state roads was built prior to the existence of the heavy wheel loads to which the pavements are now subjected. The critics of these roads glide over this fact and make much of the tardiness with which the state highway engineers have adopted a 5-in. reinforced concrete as a standard. But the editor is yet to be convinced that any economic error was made in adhering so long to 4-in. concrete pavements. The yardage of concrete that has failed in consequence of this policy is a small percentage of the total, and it is practicable to place a wearing coat upon any of the existing concrete that proves to be too thin. The picture that the investigating engineers draw of the condition of the pavements is, we think, not such a picture as the average highway engineer from an eastern state would draw. The investigators say:

> In Southern California, field inspections indicate that as high as 30.5 per cent of the concrete pavements are in poor condition, requiring reconstruction either now or at an early date.

This sounds very bad until one asks for a definition of "reconstruction." The engineers who wrote this criticism doubtless had in mind the covering of the concrete with some wearing coat when they spoke of "reconstruction." They certainly could not have meant the tearing up of 30.5 per cent of the existing concrete, for there is no such necessity. Indeed it is the editor's opinion that not 5 per cent of the concrete needs renewal.

The report goes on to say:

> An additional 19.3 per cent is in only fair condition, serious failure having already begun. This leaves only 50.2 per cent of the pavements in this section in what may be termed good condition. In general, inspections in the southern portion of the state have indicated higher percentages of failure than in the northern portion, where failure area is only 17.7 per cent, and pavements in fair condition aggregate 20 per cent, leaving 62.3 per cent of these pavements in good condition.

Here again there is need of definitions. What is meant by these terms "fair condition," "good condition" and "failure area"? Unless defined they are likely to be misunderstood, and we fear that the public that reads these estimates of "failure areas" will be badly misled. Fortunately the public that is most interested in the report under consideration is the California public, and to them the alleged "failure areas" are open to inspection. We venture to say that not one California automobilist in a thousand would regard even 1 per cent of the concrete pavements in California as being in poor condition. To this it may be replied that what the layman fails to see, the critical eye of the engineer perceives at a glance. The editor's eye may not be as critical as that of some other engineers, but it is tolerably well trained in observing highway conditions; and to his eye there is evident no such widespread failure of California concrete roads as the report of the investigating engineers would indicate. For that reason he feels certain that were those engineers called upon to defend their criticisms, it would be found that when they spoke of reconstructing 30.5 per cent of Southern California and 17.7 per cent of Northern California concrete roads, they meant resurfacing.

The writers of this report speak of their criticism as being intended to be only "constructive," but the report is not written in a friendly tone. Probably this is attributable only to pride in the professional opinions of the writers, but, whatever the cause, it is not the sort of report that an engineer would expect from a friendly though outspoken brother engineering critic of his work.

Fortunately the U. S. Bureau of Public Roads is conducting an investigation of the California state highways, and we shall soon have the opinion of the government engineers on the interesting but controversial subject of concrete pavement design.

Should the Life of Highway Bonus Exceed the Life of the Payment?

In another editorial we have discussed a critical report on the California state highways. The same report says:

> Based on sound financial policy, pavements should live as long as the average life of bonds with which they are built.

We have had occasion before to take issue with statements like this. At first sight it seems logical to affirm that the life of a road bond should not exceed the life of the pavement, but analysis shows this to be a fallacious economic policy. Let us consider, for example, the application of such a policy to steam railways. The life of railway bonds has usually been 20 to 50 years. The life of railway ties has been about 10 years, and of rails 20 years; hence the composite life of the track has been about half the life of the bonds. Was it a sound financial policy thus to make the mortgage on a railway mature long after its track had been renewed? Unquestionably it was, so long as bonds were not issued to pay for renewing the track. And there are conceivable conditions under which it might be economic even to issue bonds for renewals, although this has rarely been done.

The real economic questions are these: First, will the annual saving effected by the highway (road or railroad) exceed the interest charges upon its cost? Second, can the average man who uses the highway make a greater profit from his capital than if he invests it in highway bonds? The first needs only to be mentioned, but the second question seems to require discussion.

The taxpayers of a state may elect to build roads without issuing bonds, by meeting construction costs from current tax assessments. In this case they regard their money as being worth less to them in their own business than the 5 or 6 per cent bond interest rate. Or they may elect to build roads with money raised by the sale of bonds; in which case they regard money invested in their own business as being able to earn more than 5 or 6 per cent annually. Since both the original cost of the highway and the cost of renewals must ultimately be paid by the taxpayers, there is no fundamental economic reason why the taxpayers might not find it profitable to issue bonds for the renewals as well as for the original construction. This they could do so long as money invested in their own private businesses would yield a higher profit than the current bond interest rate. But, due to the natural extravagance of politicians, it is ordinarily wise not to permit bond issues for renewals of highways, because of the danger of improving more highways than is economically justifiable. This, it will be seen, is quite a different generalization than the one above quoted.

Every economic highway increases the value of the land that is tributary to it. The earliest paved roads in some states were of plank. Then came gravel roads, then macadam, then some more durable surfacing. Now if every one of these four successive types had been paid for by money secured from the sale of bonds, maturing a century hence, there would not necessarily be any lack of economic wisdom in having thus financed their construction. If, for example, the farmers along the roads thus built had been able to develop their land and increase their profits as a result of these successive road improvements, to such an extent as to justify the improvements, and if the farmers could borrow money at a less rate on the road bonds than they would have to pay for personal loans at their local banks, then those farmers would have been wise not merely to bond the original plank road but every successive renewal of the road surface.

Engineers who criticise highway bonds of longer term than the life of the pavement are prone to forget that money in the hands of the average taxpayer can be made to earn a greater profit than a bond interest rate. This oversight would not occur were they accustomed to solving economic problems of a broader nature, such, for example, as confronts the chief executive of a railway company. It would be difficult, we believe, to find a single railway president who would veto a railway bond issue on the ground that the railway track would have to be renewed before the maturity of the bonds. Yet many a good engineer sees nothing but wisdom in such a statement as the one we have quoted at the beginning of this article.

A Return of Efficiency

Watchers of weather vanes and straws will find a worth while observation in the following bit of information furnished by Charles B. Johnson & Son, General Contractors, Chicago, from their construction records of four industrial buildings of comparable size, character, and circumstances of construction.

	Approximate brick laid per man per day.
Job No. 1, about 1 year ago	400
Job No. 2, about 10 months ago	875
Job No. 3, about 5 months ago	950
Job No. 4, about 1½ months ago	1,300

Efficiency improvement in 10½ months, 325 per cent.

In commenting on these figures, Mr. Johnson states that while Nos. 1, 3, and 4 are properly comparable, and Job No. 2 was similar in many ways, certain features of the latter afforded easier work than the others. All of the buildings are located in or near Chicago, and the bricklaying on each was in straight 8-hour days with no overtime work.

The editor of Engineering & Contracting believes that his readers will share his feelings on this matter. He rejoices at the effect which such improvement will have on the building industry. He does not rejoice in the thought that hard necessity has wrung this better output from the men, nor does he believe that in most instances hardship has been more than a stimulus to awaken men from four years day dreams in which the necessity for conscientious effort was forgotten. Four hundred brick is not a day's work; thirteen hundred is at least aprpoximately such and indicates the definite intention of giving value received—an indication at which we may all rejoice, for in this intention lies a desideratum of healthy prosperity all too slow of recognition by both workers and capitalists.

Sidelights on the Engineer's Employment Problem

Dr. F. H. Newell, Past President of the American Association of Engineers, addressing the Boston Chapter on Feb. 11, said of the present difficulty experienced by engineers in obtaining employment:

> There seems to be little salesmanship practiced by the average engineer in search of a position. One of the greatest difficulties met with by employers in finding new men is in securing from the applicant a clear statement of his qualifications for the position desired.
>
> The remedy must come through education all along the line. Engineering publications, societies, clubs, and most important of all, the schools and colleges, should instruct in the necessary business of going after the job.
>
> If a man would make it his business to get acquainted with all the men he could in his own line of work and then hold those acquaintances he need never fear not being able to find work. Someone of these friends will usually have a place when the occasion arises, or will know where a situation may be found.

In mentioning the recent layoff without even a full day's notice of over 40 members of the engineering department of a certain railroad, Dr. Newell said:

> If this practice is to continue, if it is to be considered ethical, then the engineers-to-be in the schools and colleges should be informed of these conditions, so that they may know what they will be up against in their coming work as railroad engineers.

Dr. Newell, who has employed a large number of engineers, said that in his experience a man was advanced not for what he could do in his own line of work, but because of ability in other lines, such as hobbies and the like, for capacity in other things indicates ability to carry further responsibilities in the daily work.

The Chicago Good Roads Convention

To the Editor: In the program of the Chicago Good Roads Congress and Machinery Exposition as published in Engineering and Contracting of Feb. 2, there are approximately 30 officials and contractors listed to preside or to give talks. Of this number, three are located west of Chicago (two west of the Mississippi). There are 17 coming from and east of Pennsylvania and, with two exceptions, north of the Mason and Dixon Line.

Is this "corner" on the discussion of "good roads" due to lack of interest in the rest of the United States? Certainly there is much to be learned at these meetings.

In the same issue of Engineering and Contracting is an estimate of the 1921 expenditures for good roads. The definite figures given total approximately $212,600,000. The corner referred to will furnish approximately $46,500,000 of this amount. It has often been said that money talks, but apparently not in this case.

Boulder, Colo. J. B. MARCELLUS.

Formulas for Determining Width of Roadway

To the Editor: On Page 99 of your issue for Feb. 2 appears a letter from me in which the main feature is left out, namely, the correct formula for deducing the maximum number of vehicles per hour per line of traffic. This should read:

"Maximum number of vehicles per hour per line of traffic

$$= \frac{5280 \times \text{average speed (miles per hour)}}{\text{Headway}} = \frac{5280 \quad S_a}{F\left(\frac{S_m^2}{10}\right) + V}$$

Referring to my articles in your issue of April 2, 1919, it will be seen that headway $= D \times F + V$ was found to equal $\frac{S_a^2}{10}$. Thus headway $= F\left(\frac{S_m^2}{10}\right) + V$.

Mr. Barnett's error in his article in your issue of Sept. 1, 1920, lay in overlooking the denominator 10; thus his values would be quite too small. For example: Average speed = 10 miles. Maximum allowable speed = 20 miles. Using same constants.

Barnett "formula, $\frac{5280\ S}{2S_m^2 + V}$ gives $\frac{5280 + 10}{2 \times 400 + 15}$ $\frac{52800}{815} = 65$ vehicles per hour.

My formula $\frac{52080\ S_a}{F\left(\frac{S_m^2}{10}\right) + V}$ gives $\frac{5280 \times 10}{2\left(\frac{400}{10}\right) + 15} = \frac{52800}{95} = 555$ vehicles per hour.

H. J. FIXMER,
Paving Engineer, Board of Local Improvement.
Chicago, Ill.

961,635 Motor Trucks in United States.—According to figures compiled by statisticians of the B. F. Goodrich Rubber Co. there are now 961,635 motor trucks in the United States. The compilations are based on the actual truck registration figures for 30 states and estimates of motor vehicle registrars of the 18 other states which do not segregate motor truck and passenger car registrations. Many states which have not so segregated motor truck and passenger car licenses in the past have arranged to do so this year. Consequently future estimates can be made with a greater degree of exactness. According to the Goodrich figures, New York led all other states by a substantial margin with 132,524. Ohio came second with 83,300. Pennsylvania, which ranked third in the number of motor vehicles of all kinds, dropped to fourth place in the truck list, Illinois taking third place with 64,995. Pennsylvania's trucks totaled 52,605. The next six states in the list were: Massachusetts, fifth, 51,386; Michigan, sixth, 45,773; California, seventh, 35,857; Indiana, [illegible]. Texas, ninth, 30,000, and Washington, tenth, [illegible]

It is interesting to note that 27 states, more than half the total number, had 10,000 or more trucks. Of this number, the large majority were states where considerable manufacturing is done. The agricultural states, however, were well represented, and it is safe to predict that in a few years they will be in the majority. The largest increase in truck registration during 1920 was shown by Florida, which jumped from 2,239 to 10,448, a gain of more than 300 per cent. Massachusetts jumped from 42,000 to 51,386, Michigan from 36,863 to 45,773, and Wisconsin from 10,887 to 16,205.

Highway Traffic Records

In a report submitted at the last annual meeting of the New Jersey State Association of County Engineers, the Committee on Present and Future Traffic Conditions, of which Mr. J. L. Bauer is chairman, gave the following information collected in reply to a questionnaire covering traffic data in various parts of the United States:

On the Lincoln Highway in Pennsylvania, between Philadelphia and Trenton, it is estimated that in the year 1918 a total traffic of teams, automobiles and trucks was had of 225,000.

In the County of Los Angeles, California, in various months in the year of 1919 and on eight different roads the traffic ran from 2,000 in 24 hours up to 7,200 in 24 hours, the count being made on four classes of traffic, namely, horse, motorcycles, automobile and motor trucks. The estimated tonnage was from 3,064 tons in the first case mentioned to 8,832 tons in the second case mentioned.

At the city line of the city of Seattle, Washington, at South Park in July, 1919, the total daily traffic ran from 700 to 2,070, counting about eight hours per day. The counts were made on the following units:

Motorcycle.
Touring cars.
Buses.
Trucks under 2 tons.
Trucks, 2 to 5 tons.
Trucks over 5 tons and truck engines.
Light rigs and wagons, horse drawn.
Heavy rigs and wagons, horse drawn.

In Allegheny county, Pennsylvania, in various months dur-1919 counts were made on 23 roads for period of 7 days each and for 12 hours each day. The total counts for the seven days on each road ran from 1,579 vehicles to 15,442 vehicles, being based on the following units:

One horse empty truck.
One horse loaded truck.
Two horses empty truck.
Two horses loaded truck.
Four or more horses empty truck.
Four or more horses, loaded truck.
Motorcycles.
Runabouts.
Touring cars.
Buses.
Auto trucks, empty.
Auto trucks, loaded.

In Union county, New Jersey, the traffic census made on four successive Saturdays and Sundays in the early summer of 1918 at four of the densest traffic roads in the county showed a total traffic census for 24 hours, taking the average of days of observance at from 4,500 to 12,000 vehicles. Two of these points registered very close to the figure 12,000 vehicles in 24 hours in each day's test. The units employed were:

Motorcycles.
Horse drawn vehicles, empty.
Horse drawn vehicles, loaded.
Pleasure automobiles.
Auto trucks.

Daily traffic for the new Hudson River tunnels between New York and Jersey City, as forecast by the Tunnel Commission, will be as follows:

1924, date of opening of tunnel, 16,500 vehicles daily
1929, 25,900 vehicles daily.
1934, 37,800 vehicles daily.

The amount and increase of traffic over four New York City bridges over the East River in a period of seven years is given below:

	1912.	1919.	Per cent increase.
Brooklyn Bridge	4,000 daily	6,700 daily	67
Manhattan Bridge	4,800 daily	21,400 daily	345
Williamsburg Bridge ...	6,000 daily	16,300 daily	172
Queensborough Bridge ..	3,500 daily	18,700 daily	435

Our National Highway Problems*

By THOS. H. MACDONALD,
Chief U. S. Bureau [illegible]

Prefatory to this discussion on the highway problems which are national in character, it should be understood that present conditions are such that a large program of highway improvement should go forward, now and without delay. Funds are available; the state and Federal highway departments are ready to award highway contracts for large mileges. It is estimated that from all sources approximately $622,000,000 is available for highway work. Admittedly thre are many and grave problems in our developing highway program which must be met; still with more than 3,500,000 men unemployed and with the railroads eagerly offering transportation for the necessary materials, there is every justification for vigorous action to inaugurate a large public works program with confidence that the problems will be adequately solved as, and when, they arise.

New Requirements Confront the Highway Builder.—Nationally we are in a transition and reconstruction period for many causes, and as is to be expected, the highway question is one of those acutely affected by these changing conditions. The requirements with which the highway builder is contending today are so new that there has been no time to permit the teachers to instruct accurately from the experience of the past. The man who must do, and who will be held responsible for the results, is confused by the contradictory solutions which he and others of his class have thrust upon them. As usual, we are in a great hurry. We cannot wait for the teacher to develop his theories, and we insist that the doer engage upon a vast program of construction entailing expenditures far beyond our extreme conceptions of only a few years ago. We have been turning the clock ahead at a whirling rate. Fortunately, there has been a powerful brake upon our ability to expend funds, through the very physical handicaps imposed by the task itself. If labor, if rail transportation, if materials are not to be had, it is impossible actually to pay money out of the public treasuries for these purposes.

The highway engineer and the highway administrator are not guaranteed a safe passage through smooth waters, after avoiding the Scylla of a single problem on the one side, or the Charybdis of some other problem on the other. In the development of the highway program in this nation there is involved not one, but a large number of major problems, so extensive that they will constantly demand very large expenditures and the allocation of a great amount of labor and materials to this purpose by the public as a whole, in return for highway service, rendered primarily to the individual, but collectively, to itself. So let us not hope or expect ever to find the final solution for all highway problems, for they will continue on to the end of the chapter, yet they will not be the same, or, at least, if fundamentally the same, will appear in different guises and with many modifications.

Highway Problems of Engineering Can Be Solved.—These highway problems which are of an engineering nature are capable of solution if adequately attacked; those which are economic are also capable of solution, but in principle rather than in detail. The application will need always to be localized. Of these two classes—certainly not minimizing either—the most immediately serious are economic rather than engineering, and of the economic problems the determination of the amount and character of service which is to be required from the highways is the most important. Only in a few of the more advanced states does an adequate conception exist as to the traffic—present and prospective—which must be carried over the highways. The character and amount of traffic which the highways must carry can, through painstaking studies, be reasonably determined. Such a study should precede the settling of the second problem which is of immediate importance; that is, the mileage rate of improvement. For example, let it be determined within any state that only the high-class, heavy-duty pavements will be constructed, and automatically the rate of progress has been fixed. There are now two distinct theories of improvement. First, the one which seeks to extend a comparatively limited mileage of high-class roads annually as the funds and available materials and labor will permit. Second, the one which seeks to build a comparatively large mileage of highways to a usable condition in the shortest time possible. This second theory automatically determines that a large percentage of such mileage will be of the lower-cost roads with their well-known traffic limitations.

Early Establishment of Sound Economic Principles Needed.—The liberty has been taken with the title of this paper to interpret it as meaning a diagnosis rather than a prescription, but it may be pointed out here as indicating the need for the early establishment of sound economic principles in the administration of our highway work, that the first theory is being applied to some states where assuredly a large mileage of development roads of the lower cost types would serve the traffic under present conditions and for a long time in the future, and the second theory is being applied in some states where such type of roads have already become a liability rather than an asset. The Bureau of Public Roads has, within a few days, been requested to revise downward its mnimum designs and specification requirements for heavy traffic main roads, in one of the most populous states, where the truck traffic is growing by leaps and bounds. At the same time, we are approving plans for roadways in some of the thinly populated sections where, although in our judgment the investment is sound, nevertheless, at the rate of improvement possible within the funds that are and can be made available, the mileage of improved highways will not be adequate within a reasonable period to take care of the development of traffic. Recently there has appeared a most severe criticism of the engineering and administration of a state highway department which has provided good highway service on a selected system of roads into practically all parts of a large state with a minimum expenditure of time and funds. The balance sheet for this system of roads is neglected. The ratio of returns to investment is forgotten because a very moderate percentage of the surfacing has failed and is now in need of reconstruction. Is it any wonder that the necessity for an understanding of the economic problem is given a super position?

Economic Problems of State and Federal Highway Administration.—This discussion relates more particularly to the economic problems of state and Federal highway administration, which, in a major sense, has been confined to a limited percentage of roads. It is estimated that about 8 per cent of our total road mileage is covered by the state systems on which the state and Federal funds are concentrated. The other 92 per cent of the roads carry much traffic, and the same general discussion applies to each class, but the necessity for a decision as to the expenditures of funds for the extension of a comparatively large mileage, or their concentration on a short mileage of high type roads, relates chiefly to this small percentage of highway mileage. The total road mileage of the United States would encircle the globe nearly 100 times. We are now largely concentrating the Federal and state engineering and administration upon only one-twelfth of this total mileage, and there is a demand for an even smaller concentration of these funds, particularly those which have been appropriated by the Federal Government.

Just now we have literally a pocketful of money. Funds have been made available in large amounts by the Federal Government, the states, the counties and even smaller districts, which have accumulated because of non-expenditures, but we should not hynotize ourselves into the belief that this condition will continue to exist, unless the balance sheets show profits on these expenditures in the way of highway service to all of the people from whom these funds are contributed. The earning capacity of our roads must be demonstrated. There are plenty of communities, even as large as a whole state, which have already bonded themselves to their legal limit to provide the funds that are available now. Admittedly these limitations are arbitrary rather than fixed by economic considerations. With the task of highway improvement only begun, it is apparent that either new sources of revenue must be found, or these limitations must be changed. I have faith that these limitations can and will be raised to permit of the continuation of a large program of improvement, but such a continuation will come to be more and more dependent upon the balance sheet which we are able to show of profits derived.

The fact that there is not complete concurrence in the concentration of the necessary funds for the building of the better class of highways is well demonstrated by some-of the recent measures which have been put before state legislatures, which would require the spreading of the highway funds over large mileages of the lower cost roads, and would effectually prevent the building of the higher cost surfaces where the traffic absolutely demands them. Herein lies one of the chief virtues of the Federal Aid Road Act, and particularly in the provision of the act which requires that the Federal funds must be allocated to projects of a substantial construction. Serious problems are confronting the law makers of both the Federal Government and the states to provide the ways and means for securing sufficient revenues to meet the expenditures called for in the public budgets, even though these be trimmed and cut until they place insurmountable limitations upon the development of many of the highly advisable public activities. It must be clearly apparent to the fair-minded that the unanimous support which has been given the Federal Aid Road Act by those in administrative control of the state highway departments, has resulted from the helpful and stabilizing influence which the principles of this act have brought to bear upon the development of highway legislation and highway policies. We are passing through a period in which the development of these policies in accelerated, but is not the whole history of the highway movement in this country a succession of steps from one phase to another?

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*[illegible] Feb. [illegible] before the Good Roads Convention of the American Road Builders' Association.

The steps which we take now are of greater consequence because it is well demonstrated that the use of the highways has increased from 500 to 1,000 per cent in a period of perhaps 5 years. There are rural highways contiguous to centers of population of less than one-tenth that of our largest cities which today carry as high as 12,000 to 15,000 vehicles during the days of maximum traffic. Assuming that this statement of facts demonstrates the rapidly changing economic conditions which must be encountered, does this not present the problem of insuring stability in the personnel of the highway administrative bodies who are responsible for the development of economically sound policies?

Administration of Highway Affairs Should Be Stabilized.—Next to the determination of the economic problems, perhaps none is of greater import than the stabilizing of the administration of highway affairs. It has been pointed out by competent observers that one of the reasons that the highways in England are carrying extremely heavy concentrations of traffic without serious deterioration, is the continuation in office for long periods of competent engineers who have thus been able, through intimate and continuous observation, to apply for the benefit of the locality the knowledge gained at the expense of the community itself. Let it stand out as a bold, unchangeable fact that the public pays for the education of its public servants. Some one has remarked that a change of employes is likely to prove only a change of faults, and there is such a demand now for highway engineers that it must be understood that every man whose education and experience have been along this line grows more valuable to the community with the years of his experience in dealing with the particular problems of the community.

The administration of the Federal Aid Road Act has pointed out certain other problems of a major character. One of these which should be remedied at once is the failure of a large group of states to provide state revenues, as such, to meet the Federal funds. About one-third of the states are in this category. Some of these have been limited, through constitutional inhibitions upon their power to raise revenues for internal improvements. It is apparent that in those states which depend upon the counties or districts to supply funds to meet the Federal Aid appropriations without assistance from the state, the local interests will demand consideration. This influence has not yet seriously affected the logical development of the most important state highways, only because the roads in the different communities which are of the largest importance from the state viewpoint have also been of major importance to their respective localities. This being true, great progress has been made even in the states having no state revenues, upon the development of state and interstate systems. But to be of state-wide and nation-wide service, the improvement of the system must go forward in the communities which can ill afford the luxury of main line highways no matter how badly they are needed.

The immediately local use of the highways and the ability of communities to pay, bear a reasonably constant ratio to each other, diminishing or increasing together. But a study of the states shows that interposed between the wealthier communities are those which, although devoting a greater proportion of their wealth to highway improvement, cannot in fairness be required to continue main line highways to complete the state and interstate systems. Only from state and Federal funds can the development of such systems be assured. This same general principle holds true for the United States as a whole, and it appears that in the near future favorable consideration will be given to the recommendations of the Secretary of Agriculture and the Bureau of Public Roads, that the present equal co-operative funds required from those states having large areas of public lands which are non-productive of revenues but are highly exhaustive of the funds since the highways must be continued across these great expanses, will be decreased in proportion to the percentage of the public lands within their borders.

The Maintenance Question.—And after roads, of whatever type, are constructed, comes the major problem of maintenance. Rather let it be said that if the task today is to provide highway service, we cannot afford to wait for the construction of new and modern types of highways. The maintenance should be carried forward now on roads improved and unimproved. The returns will more than compensate the cost. If there is one problem which the road builders of the United States as a whole must learn, it is that of highway maintenance. The continuity and long radius of operation of the motor vehicle require a development of maintenance organization and maintenance expenditures not heretofore required; but in the same fact lies, because of the service rendered, the justification for the expense involved. We cannot neglect the simple methods of maintenance which have demonstrated their utility. The harrow, the road drag, the blade grader, have a high degree of utility in combination with the motor truck and gas tractor. One state engineer remarked that the widespread use of these simpler maintenance tools in his state saved his whole program of higher cost construction, because of the better highway service provided over a large mileage.

As has been pointed out, we have concentrated state and Federal highway organization and funds upon a small mileage of roads, but because service is demanded from all of the roads we cannot neglect the upbuilding of the county organizations. Smaller than county organizations should be done away with as soon as possible, and the administrative conduct of the work in the counties concentrated under competent highway engineers. There should be a correlation between the work of these county engineers and the state highway departments. Much of the more involved technical work such as the design of bridges, the planning of standards, designs, development of specifications, can be made applicable not only to state but to county highway work, and the counties should have the benefit of the guidance and support of the state organization. The closer the correlation of the work of these two agencies, the greater service will be rendered to the public, and the more enduring and more generous will be the public support.

Engineering Policies and Public Demand.—The fear arises that this discussion which started as a diagnosis, is becoming argumentative and confined too nearly to the economic and administrative rather than the engineering questions which are of national import. There is too widespread a feeling that our highways are not proving adequate under the traffic, and frequently newspaper scare-heads appear that funds are being wasted. Examine any large program of construction honestly, and usually the only conclusion that can be reached is that the engineer has builded as well as the legislative and political control has allowed, and not infrequently the engineer who has produced the highest class results has been displaced because of his inability to stretch the dollars into a larger mileage of roads. In many large programs recommended engineering policies have been mutilated beyond recognition through an attempt to meet the apparent public demand for more miles of road. During the past year great progress has been made in directing public attention to the fact that highways must be designed with painstaking care and with scientific knowledge of the local conditions which must be met, and this perhaps the greatest of our national highway engineering problems today—the design of highways which will use the most available materials—which will take into consideration not generally but specifically, the soil and drainage conditions, the topography and all other local phy[illegible] bear upon the durability and cost of the construction.

Let it be clearly understood, however, that the engineering and the economics cannot be separated, and that engineering is best which does not design against every possible failure at an impossible cost, but which limits the number of failures to a low per cent.

A major engineering problem which is national in its scope is the early determination, by agreement if possible, between the road user and the road builder, upon the maximum loads which are to be carried. Although our motor vehicle registration has reached over 9,000,000 vehicles, the determining factor in the design of the higher cost roadways is the motor truck which now constitutes not more than about one-tenth of the motor vehicles registered. A recent traffic count in California shows the use of the highways by motor trucks amounts to approximately 12½ per cent of the total traffic. There is no doubt that the design of motor vehicles has been treated largely from the mechanical consideration of the construction of the vehicle itself. The development of these vehicles has taken place so rapidly that the adaptation of the vehicle to the roadways over which it is to be operated has been seriously neglected. On the other hand the highway engineer is forced to give consideration, in his design of modern highways, to the vehicles which are to be operated over them, and it is now time that the interrelationship of the design of highways and the design of motor vehicles be recognized as a fundamental engineering problem without which the development of neither can go forward in a manner that will bring to the public the greatest service from the combination.

The Two-Hundred Millionth of an Inch and the Ten-Thousandth Part of a Second

Yes, these figures represent actual measurements, incredible as they may seem to most of us. And if their value in the field of engineering is not at once conclusively apparent, we must remember that other achievements which at first appeared as of interest only in the fields of pure science have later developed most practical uses.

The extreme refinement in linear measurement is the invention of Prof. Whiddington of Leeds University, England. It depends upon the development of sound in a special telephone receiver when the coincidence of frequencies in two electric circuits is disturbed by a variation in the position of condenser plates. It is about 200 times finer than the best previous measurements, which were dependent upon phenomena of light.

A list of results so far accomplished through the Whiddington method is not at hand, but we have the statement that measurement has been made of the deflection of a solid wooden table due to the weight of a coin placed upon it.

To Prof. Albert A. Michelson of the University of Chicago goes the credit for the most accurate method of angular measurement. This is known as the "interference method," and has attracted much attention on account of the astounding dimensions of some of the fixed stars recently measured by it at the Mt. Wilson Observatory. An angle of one ten-thousandth of a second is, to say the least, difficult to think of. Perhaps it will help to consider that this is the angle which would be subtended by the width of an ordinary pencil lead at a distance of about 1,000 miles from the eye.

In taking measurements by this method, the mirror of a reflecting telescope is covered with a shield in which are two parallel adjustable slits. As a result a series of interference bands become visible; and when measurement is made of the distance apart of the two slits after they have been adjusted to a spacing at which the fringes of the bands disappear, it becomes possible to calculate the angle subtended by a star's diameter.

Convention of U. S. Good Roads Association.—The 9th annual convention of the United States Good Roads Association will be held at Greensboro, N. C., April 18-23. The Bankhead National Highway Association will hold its convention at Greensboro, on April 21 and 22. There also will be an exhibition of road machinery, materials, trucks, tractors and automobiles. J. A. Rountree, Greensboro, N. C., is direc[illegible]

The Traffic Census

There is a general agreement among all conversant with highway conditions as to the immediate necessity for thorough and systematic work in highway research, and there are already under way well-organized efforts toward this end. Even a brief study of the problems of highway research shows that many of them of the most fundamental character require for their solution a comprehensive knowledge as to the traffic which moves over the highways. It is therefore of the utmost importance that traffic census work be undertaken and this information collected as rapidly as possible. Some of the features that should govern a traffic census were outlined by A. N. Johnson, Dean, Engineering College of the University of Maryland, in a paper presented Dec. 14 at the 6th annual convention of the American Association of State Highway Officials. An abstract of the paper follows:

Traffic Records in the United States.—For the most part, the traffic records made in this country have been of spasmodic character, and with one or two exceptions have not been taken with any very definite purpose in view other than to record some information which might prove interesting to examine.

The first traffic census taken in this country for any extended period was made in Illinois, 1906-7, where the traffic was counted at some seventy-odd stations continuously during a two-year period on an average of four times a month. The data collected, however, are chiefly valuable from an historical standpoint.

The only state reporting that systematic traffic records have been made within the past few years is Maryland, where, since 1912, one-day counts each month have been maintained on all of the state highways. In 1912 there were about 50 stations, to which additional stations have been added as new sections of state highways were built, until at present there are 191. These traffic records have been used to a certain extent to study maintenance costs and have been very valuable indeed in this connection.

The Basis of a Traffic Census.—Let us now examine some of the considerations upon which to base a traffic census and, from the requirements to be met, deduce as much of the detail as possible as to the manner of making such a census.

The great disparity between the amounts of traffic that use a road prior to its improvement and subsequently is to be noted everywhere. This fact makes a general traffic census over a system of roads which have not been improved of little value, although there will probably be certain points on all such systems of roads prior to their improvement where a traffic count would be of assistance to determine something both as to character and amount of traffic that such particular sections of road might be expected to carry after improvement.

A general traffic census, such as has been taken in a number of foreign countries, particularly in England, France, and Belgium, can not have the same application here, except in those localities or state where the roads have been generally improved and where, as a consequence, highway traffic has developed and the principal routes of travel have been defined. Also as a result of the general improvement of the highways the amount of traffic to be noted may be expected to give a fairly accurate indication of the total use to which those communities find it at present profitable and convenient to use the highways.

There are few states in which the highways have been thus generally improved where a traffic census should be of value in this sense. In such a list are to be included Massachusetts, New Hampshire, Connecticut, Rhode Island, New York, New Jersey, Delaware, and Maryland. To this list may, perhaps, be added Ohio, Wisconsin, Minnesota, portions of Pennsylvania, and California. Outside these states there are a number of localities centering around large cities where the roads for a considerable distance have been materially improved, in particular about Chicago, Detroit, Kansas City, St. Louis, Portland, and Seattle. The improved roads about these cities, extending for 15 or 20 miles, are generally confined to the neighboring county.

Purpose of a Traffic Census.—From a summary of traffic censuses that have been made in other countries and various states, it will be noted that there is a wide variation as to the details. Before these can be discussed it is necessary to analyze the purpose of a traffic census and then to adopt such a method of taking the census as will give the data necessary to serve the purpose sought. It is evident that more than this entails unnecessary expense, while less makes the expense incurred of little or no value.

Some of the purposes of a traffic census may be outlined as follows:

(a) For the economic evaluation of a highway, i. e., to determine its worth as an investment, or how much may be safely invested in highway improvement.

(b) To find the seasonal variation in the use of a highway.

(c) For the proper design of a highway.

(d) For a rational allocation of reconstruction and maintenance funds.

(e) To obtain the cost of operating traffic over the highways.

(f) To furnish data for the formulation of regulations governing vehicles and the manner of their use of the highways.

Let us examine what will be required to furnish the data necessary for the purposes above outlined. First, to evaluate the economic worth of a highway it is necessary that both the amount and character of traffic using the highways be known, not only on a few sections of road but for a large mileage constituting a system of highways. We should also have some knowledge of the amount of traffic on the auxiliary roads to such a system.

To determine the total amount of traffic it is necessary that we know the total number of vehicles of all kinds. We should also know what proportion of these vehicles are for freight and what for passengers. We should want to know the number of passengers as well as the net tonnage transported during the whole year and at different seasons of the year, together with some indication of the nature of the products, as agricultural products, both raw and manufactured, manufactured goods, products of mines and quarries, etc.

To allocate the maintenance funds the amount of traffic and its character should be known over all sections of the highways. This same information would also be used to determine the maintenance cost per unit of traffic.

To determine the wear due to traffic on different highways of similar construction, it should be possible to compare the relative amount of different kinds of traffic, the proportion of light and heavy vehicles and of horse-drawn and motor vehicles.

For the proper design of a pavement we should know the heaviest loads to be carried and their frequency, to aid in designing the thickness, for which there will be required also much data from other sources. To determine the width of pavement, the maximum amount of traffic to be carried in each direction for a given period during the day, and whether the bulk of the traffic changes direction according to the time of day, would be the governing factors in deciding whether a pavement should be widened to a three-track or four-track way.

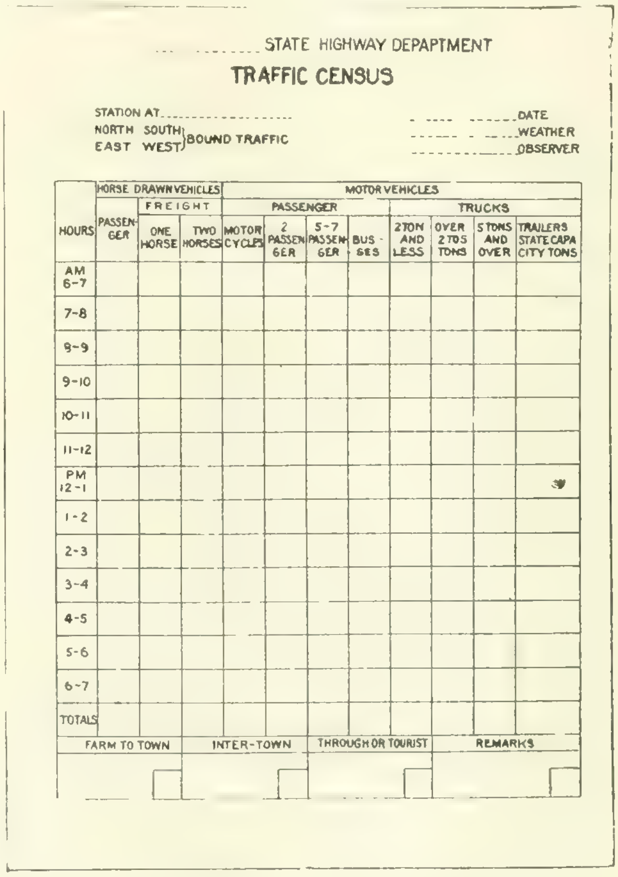
The cost of operating traffic over the highways is one of the most significant factors concerned with the economics of highway building and maintenance. Until the cost of highway transportation and the elements that affect it are known and applied, true economy in the construction and maintenance of roads can not be attained. The fundamental requirement for data for such a purpose is a reliable traffic census. Not that the census in itself will answer our problems, for there are many experimental data necessary, which are to be secured only by patient and exhaustive study. But these data will be of no practical application until we know the traffic over our highways. For this purpose we shall require to know the total numbers of each class of vehicle using the road and the total tonnage.

To formulate regulations to control traffic, general divisions, as horse-drawn and motor-driven traffic, are evidently essential as well as the number of passenger and freight motor vehicles. The relative frequency of heavy and light loads will be useful to determine the necessity of traffic segregation, while the total amount of traffic using a highway will help to develop rationally other limitations that may be necessary to impose upon those using the highway for transportation.

From what has been said as to the purposes that are to be served by a traffic census, we may now turn to a discussion of the elements of a traffic census which will give the required information.

We have to answer three principal questions: First, as to where traffic enumerations shall be made; second, as to how often—that is, their frequency and duration; and third, as to what shall be enumerated.

Where Traffic Counts Should Be Taken.—Traffic-census stations should be established close enough so that the traffic over a given section of road may be determined with reasonable accuracy. They should be so close to cities or villages as to include merely local traffic that extends but a mile or less beyond the observation point. As important byroads join the main road, other traffic stations should be established. Some idea of the total number that may be necessary may be gained from the work in Maryland, where on the average there is a traffic station every 7 miles on the state highway system. Additional stations would be required if the traffic carried by the more important side roads is to be known. In England it is not necessary to have counting stations in the open country closer than every 10 miles, but they are nearer together in the vicinity of cities. Where traffic is not heavy, counts could be made at crossroads, one observer taking traffic on both roads.



.... STATE HIGHWAY DEPAPTMENT

TRAFFIC CENSUS

STATION AT.................. ....DATE
NORTH SOUTH} BOUND TRAFFIC ....WEATHER
EAST WEST} ....OBSERVER

HOURS	HORSE DRAWN VEHICLES			MOTOR VEHICLES							
		FREIGHT		PASSENGER				TRUCKS			
	PASSENGER	ONE HORSE	TWO HORSES	MOTOR CYCLES	2 PASSENGER	5-7 PASSENGER	BUSSES	2 TON AND LESS	OVER 2 TO 5 TONS	5 TONS AND OVER	TRAILERS STATE CAPACITY TONS
AM 6-7											
7-8											
8-9											
9-10											
10-11											
11-12											
PM 12-1											
1-2											
2-3											
3-4											
4-5											
5-6											
6-7											
TOTALS											

FARM TO TOWN	INTER-TOWN	THROUGH OR TOURIST	REMARKS
☐	☐	☐	☐

Suggested Tally Sheet for Traffic Census.

Frequency and Duration of Traffic Counts.—Reference has been made to the conditions under which a general census may profitably be made; that is, a census taken over a widely spread system of roads. Unless such a system has been improved so that traffic uses the roads of the system in preference to the other near-by routes, there is little value to be gained from a widely extended count of present traffic throughout the year. If the roads of the system are not generally improved, it is recommended that counts be confined to two weeks during the summer and fall, a week at a time, counting the traffic for seven consecutive days.

Traffic records throughout the year may be made on certain roads of an unimproved system near larger cities, to which may be applied a traffic factor obtained from observed traffic in other localities of similar environment, but where the roads have been generally improved.

With the data thus collected it would be possible to form an estimate of the expected traffic over a proposed system of state roads yet to be improved, that should closely approximate the relative amounts of traffic the different highways would carry, while giving a reasonable estimate as to actual amounts of traffic that may shortly be expected to develop. Such studies would furnish a sound basis for the determination of the routes and sections of routes most needed for immediate improvement.

Where a traffic census is to be taken over an entire state system of roads the enumeration should be taken with sufficient frequency to establish the seasonal, weekly and hourly variations. For these purposes it is recommended that the counts should be made on an average of four times a month, each count falling on a different day of the week, the intervals between the counts being as nearly equal as it is practicable to make them. The observations should be made from 12 to 14 hours continuously, the longer time during the summer months.

Night traffic for the majority of the roads which are not near the large centers of population, can be sufficiently well averaged by taking a few typical counts, which need not exceed four or five a year, taken at different seasons of the year. But in the vicinity of all large cities, particularly on those roads where the public makes considerable use of them for riding during summer evenings, the counts should continue far enough into the night to insure that the bulk of this traffic will be included in the summary.

After one or two years' data have been accumulated, the frequency of the counts may be reduced; from one-third to one-half the number will doubtless be found sufficient.

What Shall Be Enumerated.—It is desirable that the classification of traffic be made according to two distinct methods; (1) according to type of vehicle, and (2) according to the destination of traffic, i. e., whether its direction is toward or away from a given center, whether it is farm-to-town or town-to-town traffic, intertown, or traffic through the state. These distinctions as to destination of traffic can usually be discerned by the observer from his general knowledge of the locality and the character of the vehicle and its load, the bulk of through traffic being indicated closely enough by noting those vehicles bearing license numbers of other states or that manifestly carry tourists.

The tally sheets should therefore be divided into two parts, one according to types of vehicles and the other according to destination of traffic, the observer making two marks, one under each of the general divisions, as each vehicle passes, which will be in itself, to some extent, a check upon his work.

The classification of vehicles should be such that the tonnage, both gross and net, as well as the number of passengers can be estimated for any given unit of time. This will require that the tally sheets shall show the traffic for each hour or two-hour period throughout the day, the hourly period being the one recommended. In addition to the total tonnage, the frequency and number of the heavier units should also be shown, for it is these heavier units which determine the critical loads that the road is to carry, and the frequency known will make possible some determination as to how much relative value this portion of the traffic has, and therefore to what extent the engineer is justified in increasing the strength of the road for these heavier units over that required for the average loads which use the road.

To determine the number of passengers and the tonnage it is not necessary for the enumerator to make very nice distinction; probably two classes of passenger vehicles would be sufficient, or not more than three, to include passenger busses. A few days' count, showing the actual number of passengers and the number for each classification of vehicles, would give a factor by which the enumeration, made as already suggested, could be reduced so as to give with reasonable accuracy the total number of passengers carried over the road for a given period. To estimate the gross tonnage or net tonnage the enumerator need not keep more than three classifications, one for motor trucks of 5-ton capacity and over; one for trucks of 2 to 5 ton capacity; and one for trucks under 2 tons.

A few days' records noting carefully the type and weight of all motor vehicles according to the classification now used in Maryland,* for example, will give reliable factors for reduction to secure the gross tonnage. Likewise records in detail of the net loads carried should be made for a few days on some much-traveled road, until several thousand vehicles have been recorded, from which the net tonnage factors can readily be deduced.

These net tonnage factors would vary somewhat for different localities and possibly for the same locality at different seasons of the year, but need not cause any change in the classification to be used on the tally sheets for the general enumerations. They do, however, bring out the necessity for an experienced observer to study the conditions of traffic in different localities in order that the most intelligent and rational application possible may be made in reducing the traffic to a tonnage and passenger basis.

The Tally Sheet.—One practical consideration to be kept in mind in the make-up of the tally sheet* is the fact that the enumerators will probably be patrolmen or persons of similar limited abilities, so that it is desirable that the tally sheets upon which the actual counts are to be recorded should be made as simple as possible.

The classification recommended to be shown on the tally sheets is as follows:

Horse-drawn vehicles:
  Passenger.
  Freight—
    One-horse.
    Two-horse.
    —— horse.
Motor vehicles:
  Passenger—
    Motorcycles.
    Two-passenger.
Motor vehicles—Continued.
  Passenger—
    Five or seven-passenger.
    Busses.
  Freight—
    Two tons or less.
    Two to five tons.
    Over five tons.
    (Trailers, giving approximate weight in tons).

The tally sheets are also to show traffic classified as:

Farm-to-town.
Intertown.
Through or tourist.

The tally sheet should show the number of vehicles in each direction. For this purpose two tally sheets may be used simultaneously, one for the north or east bound traffic and the other for that bound south or west.

Each sheet is to be divided into hourly spaces 14 hours on a sheet, using additional sheets for night counts.

In addition each tally sheet should show the date of the enumeration, location of the station, weather conditions, the name of the observer, and whether the count was taken on a day of unusual traffic conditions because of some special event happening in the vicinity.

It is evidently desirable that the traffic census taken in one locality should be readily comparable with that in another, and this will be brought about most effectively if the general purposes of a traffic census are first well understood and developed and the details of making the enumerations made as nearly uniform as practicable.

Federal-Aid Road Building Reaches High Mark in 1920.—Federal-aid highways constructed last year cost more than double the average amount spent annually for 10 years in building the Panama Canal. The cost of the work completed during the fiscal year of 1920, including the amount paid by the states, totaled approximately $80,000,000. The construction of the canal is regarded the world over as a record-breaking achievement in respect to the dispatch with which it was carried out. The cost, however, was only $373,000,000, and a 10-year period was required to complete it, the average rate of expenditure being only $37,000,000 a year. Comparing the magnitude of the Federal-aid program with the entire highway program of the United States, the significance of Federal aid is readily seen. Federal money allotted to projects actually under construction at the end of the fiscal year 1920, namely, $103,925,094, was only slightly less than the total expenditure of $106,861,053 from state funds for highway construction during the calendar year 1919. In spite of untoward economic conditions, the amount of Federal-aid business handled, as represented in 1920 by the number of projects, was approximately 25 per cent greater during the single year than all previous work done under the act since 1916.

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*The Maryland classification and weight in tons of vehicles as shown on the tally sheets is as follows:

Vehicles.	Tons.
1-horse:	
Runabouts, open and top-buggies	0.362
Open spring wagons and covered delivery wagons	1.000
2-horse:	
Family carriages and hacks	.562
Delivery wagons, vans, farm wagons and dump wagons	2.500
Farm wagons, drays and vans	3.500
4-horse, farm wagons and drays	3.750
6-horse, farm wagons and vans	4.250
1-horse carts	.800
Ox carts	1.000
Motorcycles	.225
2-passenger automobiles:	
Light-weight machines	.900
Medium and heavy weight machines	1.750
5-passenger automobiles, light-weight machines	1.125
5 and 7-passenger automobiles, medium and heavy weight machines	2.250
3 and 4-passenger automobiles, inclosed (like taxicabs)	2.000
Store delivery automobiles, medium and heavy weight, with tops	2.250
¾, 1, 1½ and 2-ton hauling trucks	3.200
3, 4 and 5-ton hauling trucks	7.500
Passenger auto busses, light-weight machines	1.150
Passenger auto busses, medium-weight machines	3.000
Passenger auto busses, heavy-weight machines	4.250

A Criticism of the California State Highways and a Reply by the State Highway Board

An investigation of the state highways of California been made by engineers employed by the Automobile Club of Southern California and the California State Automobile Association. The investigation required 6 months and was conducted by J. B. Lippincott, engineer for the Southern Club; Walter C. Howe, engineer for the State Automobile Association; E. J. Brunnier, consulting engineer, San Francisco; Charles Derleth, Jr., of the University of California, and 10 other civil engineers. The report of these engineers has recently been made public, and from it we have taken the matter that follows. Editorial comment on the report will be found elsewhere in this issue.

Purpose of Investigation. — The combined membership of the two State automobile associations exceed 71,000. It is the purpose of these clubs to promote better highways and to advance and protect the interests of the automobile public. These two corporations have given substantial aid to secure the adoption of an aggregate of $73,000,000 of State and $42,000,000 of county bonds for highways, a total of $115,000,000. About half of this great sum remains unexpended. The State now has available nearly $39,000,000 for future work without the Federal aid contributions.

The clubs have taken keen interest in the passage of the Motor Vehicle Act and all general road legislation. Under the Motor Vehicle Act, members of the automobile associations are contributing in license fees a total of $760,000 annually to the State. This fund is divided equally between the State Highway Commission and the counties, and is available for road maintenance; therefore, the two institutions have a vital interestt in the policy of the State Highway Commisison. This policy not only has a direct bearing on the taxation of 535,000 automobiles and 35,000 trucks in the commonwealth, but also involves the future life and efficiency of the highways. The clubs are gravely concerned with the safety of the motoring public and feel a responsibility to the public in all projects connected with motor traffic.

The two associations realize the difficulties under which the State Highway Commission was compelled to pursue its earlier work. The construction programs of 1913, 1914 and 1915 are highly commendable. The mileage of roads built in the periods enumerated, in the face of an unsalable 4 per cent State bonds, is a most creditable achievement. Cleanness of administration and absence of scandal have been noticeable. Willful waste and extravagance cannot be charged and honesty of purpose is freely admitted.

Failures of paved highways in California have become frequent in the past two years. In consequence criticism of State highway standards and State construction methods has been so general that the board of directors of the two clubs have considered it timely to institute an engineering and economic study of all the paved State highways to determine their present conditions, their sufficiency in width and the adequacy to carry the ever-increasing volume and weight of traffic.

Incompleted sections of main trunk and lateral highways; the addition of an extensive mileage to the original program; the costs of work and the possibility of completing the system with the funds available, furnished additional motive for this investigation.

The Governor of California was invited to appoint a State representative to act with the engineers of the automobile clubs, but declined since a similar investigation has been authorized by him under the direction of the Federal Bureau of Roads. However, the State Highway Commission has cheerfully furnished from its records all data that has been requested.

The engineers of the automobile clubs began their studies in July, 1920. The work has been continuous and uninterrupted up to the present time, and involves expenditures exceeding $30,000. Valuable data have been collected concerning weight, speed and volume of traffic; detailed inspections have been made of all paved roads on the State system; laboratory tests are being conducted at the State university; and an elaborate highway bibliography has been assembled. In addition, the engineers of the two clubs have prepared extensive reports which have been filed with the respective organizations.

Report Intended to Be Constructive.—While these reports may seem critical, it has been the first object to be constructive in criticism. Where road failures have been found, these reports attempt a determination of the cause and indicate possible remedies; this with a sincere desire to profit by successes and failures made, that California's future roads may be more substantially constructed to meet the requirements of an unparalleled increase and change in the character of traffic.

Records in the offices of the automobile associations show that prior to the July, 1919, election on the $40,000,000 bond issue, the California Highway Commission agreed to carry out the following construction program:

(1.) To complete all gaps and grade or pave all main trunk highways. These were definitely specified in the campaign previous to the 1919 election and involved fifty-eight different sections.

(2.) To take over and construct entirely at State expense the county lateral system. These also were definitely specified for eight different sections.

(3.) Thirty-one additional roads were listed and added to the bond issue as desirable roads. As many of them were to be built as the balance of funds would permit.

The automobile associations, having always been very active in the promotion of good roads, finding that the two original bond issues—the first for $18,000,000 and the second for $15,000,000—had not completed any of the main trunk lines between large centers of population, either along the coast or through the great inland valleys, were very insistent with the Highway Commission that a definite program be established if these associations were to go before the public again and spend time, money and effort in aiding the California Highway Commission to carry the $40,000,000 bond issue to a successful conclusion.

Upon these understandings the above schedule was adopted as a program for the 1919 campaign. Facts show that the program as agreed upon is now being fulfilled.

Commission Failed to Profit by Experience.—The commission has lacked foresight and vision by failing to carry out adequate and sufficient experimentation, research and investigation on a broad and comprehensive scale. It has not taken advantage of the few experiments it did make.

Until October, 1920, the Highway Commisison followed a rigid policy. It used practically the same type of construction throughout the State, irrespective of the requirements of traffic, subsoil and drainage. Such a policy is economically and structurally unsound and open to grave criticism. Even the last pronouncements of October, 1920, propose a specific requirement of steel bar reinforcement for all concrete roads, no matter how the subsoil conditions may vary.

The commission apparently has no stated program directed toward aiding county highway departments. It should adopt an adequate and liberal policy at once that the counties may profit by the successes and failures in State highway experience. The selection of type of road, width and thickness, reinforcement, suitable materials for construction, standard structures, surfacing and numerous other details are of grave importance to the taxpayers of every county. Highway routings, bridges, etc., are so closely related to possible future State highway locations that they demand uniform and concerted action between State and county if wasted effort and consequent additional expense are to be avoided.

It is a matter of common knowledge that the California Highway Commission has failed to profit by a very varied and costly experience taught by innumerable failures of 4-in. concrete roads. Despite these failures it has continued to build the light 4-in. road sections in numerous instances under practically the same conditions upon heavy subsoils of questionable and uncertain character. California has continued a 4-in. pavement program when other States increased the thickness to 6 in. and 8 in.

Circumscribed Responsibility of Division Engineers.—Through a headquarters' policy which must be classed as both narrow and shortsighted, the responsibility of the division engineer has been so circumscribed that at times his work has resolved itself into mere routine, such as the transmission of bill schedule, work and purchase orders and general requests for headquarters approval. The position of division engineer is an important one, but he has lacked the authority to decide pressing and local questions. He has been obliged to refer the most minor items to Sacramento for decision. This robs the division of its individuality, takes away that responsibility which naturally should belong to the division engineer; kills his initiative and therefore affects the entire division organization.

Just criticism of the State commission arises from the constantly recurring delays in payments of accounts of all kinds.

Attitude Toward Contractors.—The commission's attitude toward highway contractors of excellent standing has been the cause of severe criticism from contractors of the soundest reputation. Highway contractors in the past have found little profit in highway work. The list of contracting firms who have become bankrupt is astonishing. Numerous instances of rigid and drastic rulings involving considerable losses to the contractor have been cited, causing some contractors to claim that the commission's policy has been one of alienation rather than one of co-operation. Such policies can only have one result: an increase in the future price bid.

The experience of the State Highway Commission is that day labor is not economical, therefore the contractor who must build our highways should be dealt with fairly and be encouraged to undertake the work under conditions which may realize him some profit. Any other course is not in the interest of the State or of ultimate economy.

There is much room for improvement and development in the commission's future attitude toward: (1) accounting and cost keeping; (2) equipment accounts; (3) amendments to specifications and contracts; (4) yearly traffic records, and a number of other pertinent subjects, all of which are dealt with in detail by the club reports.

Condition of Highways. Our examinations do not justify the statement made by the chairman of [illegible] on June 19, 1920 viz: "that in his opinion [illegible] of the State highways thus far built in California [illegible] they were laid." In Southern California, field inspections indicate that as high as 30.5 per cent of the concrete pav[illegible] condition, requiring reconstruction either now or at an early date. An additional 19.3 per cent is in only fair condition, serious failure having already begun. This leaves only 50.2 per cent of the pavements in this section in what may be termed good condition. In general, inspections in the southern part of the State have indicated higher percentages of failure than in the northern portion, where failure area is only 17.7 per cent and pavements in fair condition aggregate 20 per cent, leaving 62.3 per cent of these pavements in good condition.

Inspections show that pavement failures are closely related to soil conditions and imperfect drainage. In Southern California, of roads built on clay and adobe soils, 70 per cent have failed, and in Northern California approximately 61 per cent. On sand, gravel, decomposed granite and similar soils from 70 per cent to 75 per cent of the concrete roads are in good condition.

Criticism of Standard 5-in. Pavement.—Since these investigations were begun by the automobile clubs the State Highway Commission has increased the thickness of its standard pavement to 5 in. and proposes to reinforce it all. A 5-in. concrete slab is not thick enough to meet heavy traffic requirements.

We cannot indorse a policy that contemplates the use of expensive steel reinforcement irrespective of conditions of subsoil, traffic and drainage. The amount of steel reinforcement that is practical and economical is variable. The amounts specified by the highway commission are too much where sand, gravel, decomposed granite and similar soils are encountered and too little on boggy subgrades or on clay and adobe subsoils, especially where the thin 5-in. concrete minimum slab now specified is used.

It has been stated by the chairman of the highway commission that: "The consensus of opinion of our engineers is that reinforcing of the concrete highway is the equivalent of thickening it at least 2 in." Tests show that a 6-in. plain concrete slab has a greater traffic capacity than 5-in. sections reinforced as proposed; therefore this statement has little foundation in fact.

The high maintenance charges and reconstruction costs which 4-in. and 5-in. pavements have required during the past 7 years, particularly where the subsoil is clay or adobe, lead to the inevitable conclusion that it is more economical to build thicker and more substantial pavements.

Thicker Pavement Recommended.—We must expect enormously increased truck traffic. Wheel loads and speeds will increase unless legislation and larger license fees prevent. Congested truck traffic already required an 8-in. minimum concrete thickness with substantial reinforcement wherever the subgrade demands it.

For truck roads we recommend pavements of an average thickness not less than 6 to 8 in., depending upon subgrade, drainage and traffic requirements. Wherever the subsoil is treacherous and yielding, these concrete pavements require an amount of reinforcement proportional to the foundation difficulties to be overcome.

The highway commission should have paid greater attention to the preparation of subgrades. Experience has shown that modern traffic will inevitably crack thin concrete pavements on subgrades of heavy clay or adobe unless every precaution is taken to provide drainage and to keep the moisture content as nearly constant as possible in the subgrade materials. It is recommended that clays and adobe be adulterated by rolling into them such materials as sand, gravel, or broken stone. Everything should be done that will tend to limit the tendency for change in adobe volume with change in moisture content. The adulteration and impregnation of clay and adobe subsoils should always be extended to each side of the concrete slab to provide an equally secure foundation for side shoulders. These side foundations and shoulders should not be less than 3 ft. in width wherever the clay or adobe is questionable. The type of reinforcement used by the California Highway Commission cannot prevent longitudinal cracks on adobe; it tends only to hold the broken slab together.

Recommends Shoulders and Wider Pavement.—While rock or gravel shoulders, oil bound and sealed, are recognized as unsatisfactory and uneconomical, if built for the purpose of widening a concrete road, it is our belief that such type of shoulder should be provided on all adobe and heavy clay subsoil sections irrespective of width of pavement, primarily for the purpose of preventing storm water from working down and under the pavement to its detriment and possible destruction. In addition to keeping the moisture content more uniform, shoulder construction gives lateral support to the sides of pavement, thus reducing the known tendency to break down along the edges. With wider concrete roads this type of shoulder would only be subjected to turn out traffic; in consequence, a longer span of life under proper maintenance [illegible]

Greater width of permanent paved roadway is, however, of extreme importance. Fifteen-foot pavements without shoulders are unsatisfactory and dangerous. Modern trucks with an 8-ft. body width cannot pass on a 15-ft. roadway without inviting collision and accident. The width of all double track highways should never be less than 18 ft. on tangents; they should be widened on curves and grades. Future traffic demands a minimum width of 20 ft. for every important road. Near cities, or where traffic is heavily congested, pavement widths should be not less than 24 ft.

The state should adopt a high standard of concrete mixture, developing higher, ultimate strength than has heretofore obtained. Ten states use the same mixture as California, and thirty-seven use a richer mix.

Costs and Maintenance.—Independent of all other considerations, it is illuminating to examine the probable life of 4-in. pavements completed in 1914-1915 and the ultimate cost at the end of the average life of the bonds issued to cover their initial cost. The first cost of these pavements 15 ft. wide and 4 in. thick averages approximately $7,073 per mile, pavement and engineering costs only.

Developing maintenance costs, including surfacing, until they reach a point where it is no longer sound financially to continue repairs, we find that economically these pavements have an average life of approximately eleven years. Adding interest to the original costs, plus maintenance, together with reconstruction costs and additional interest and maintenance to the average bond life noted—in this case 25 years—the ultimate costs are obtained. These ultimate 25-year costs average approximately $67,800 per mile.

The ultimate, or 25-year costs, of pavements laid in 1914-1915, if these had been constructed to a thickness of 7 in., with proper treatment of the adobe subgrade, and using reinforcement where necessary over approximately half the mileage, would have been $53,050 per mile. This seems a conclusive demonstration of the type of pavement that would have provided the soundest investment of the people's money for the life of the bond. This analysis, therefore, confirms the recommendation as to thickness of pavement made above.

Life of Bonds.—For the first and second bond issues the last bonds will be retired in 1962. Probably long before this time many of our present pavements will have become either worn out or obsolete and their general reconstruction will be necessary. Based on sound financial policy, pavements should live as long as the average life of bonds with which they are built. Some of our 4-in. pavements have broken down in 4¾ years; practically before the retirement of any of the bonds had begun. It is estimated that all of our roads will need replacement at the end of their economical life. The total length of life of our present roads is a matter of judgment and is speculative, but the economical life of the earlier pavements is definitely determined to average about 11 years.

It is important to build more permanent roads with shorter life bonds. In this connection it is interesting to note that the State of New Jersey prohibits the use of a bond of a life over 20 years for the construction of any type of road. In that state the limit for sand and gravel road bonds is 5 years; for macadam, 10 years; for bituminous concrete, 15 years; for block or sheet asphalt, on concrete and plain concrete 6 in. thick, 20 years.

With our state bonds running many years beyond the 20-year life, it behooves us to consider the seriousness of a short life for our 4-in. pavements and to fundamentally change our policies in this regard.

Overloading Pavement Slabs.—While the State of California has built roads that have been demonstrated to be too frail and too narrow, it has also completely neglected to enforce the laws relative to overloading the pavement slab. It is apparent that if truck operators are permitted to use the highways without police supervision a few unreasonable truck drivers or operators will wreck any road system that may be built. Thinking people recognize that such a policy is improper, shortsighted and suicidal. There must be co-operation between the truck dealers, truck operators and the state authorities in the enforcement of proper traffic laws.

California should adopt a uniform motor vehicle law. Such a law is necessary for interstate traffic. Manufacturers cannot be expected to design special trucks to meet different state laws.

It is equally important that speed regulations should be enforced for trucks. The speeds at which these heavy loads travel on public highways produces impact. This road shock is especially destructive to the pavement.

Research and Experiment Neglected.—The California Highway Commission has not sufficiently and adequately conducted research and experimentation. In work of the magnitude of our highway program, the commission should set aside a budget of sufficient funds for the continuous study of special problems. Some of these are:

Relative capacity to distribute pressure on subsoils by rigid pavements of concrete, asphaltic pavements, macadam; tests of heavy clays and adobes. Investigation of subsoil drainage, in clays and adobes, in compressible soils in the presence of freezing and thawing; level records on pavements from selected sites, the effects of alkali; tests on full-sized pavements to determine more fully the relative advantages of reinforcement vs. greater thickness of slab and varying richness of mix of concrete; a study of different types of reinforcement; studies of the absorbtive power of adobe and clay to take water out of the bottom of a freshly poured concrete slab; a study of the mechanical adulteration of clay and adobe subgrades; an inquiry into possible chemical treatment; traffic studies; the effect of impact, of roughness, of surface of pavement; design of truck, character of tires, speed, etc.

These and other tests suggested by modern practice should be programmed. They would be expensive; would take time and would require a specially trained staff of assistants, but the magnitude of the work justifies such expenditures and would teach the commission and its engineers how to avoid otherwise costly mistakes.

Public Not Sufficiently Informed.—The public has not been sufficiently informed that adequate permanent roads would cost more than the estimates and bond issues have indicated. To achieve mileage of highway, roads have been built that are dangerously narrow and entirely too frail. In the three bond issues a total of 5,560 miles of state roads are proposed; only 1,402 miles have been paved, or 25 per cent. Practically no roads specified in the third bond issue have been built. Public opinion in California demands more permanent types of construction rather than mileage of highways. County roads where the taxation is more directly placed on the beneficiaries are in some instances better roads than those built by the Highway Commission. We predict that the California public will not continue to support frail construction on long-life bonds.

This report has called attention to numerous failures of concrete roads, but it is not intended to convey the impression the undersigned are opposed to the construction of concrete highways. The contrary is true. We believe that the most satisfactory type of pavement to stand heavy traffic conditions, particularly on insecure foundations, is an adequately and properly built concrete slab.

The California Highway Commission, while perhaps not legally and technically responsible for some of the conditions described in this report, is, however, the state authority having general supervision and jurisdiction over our expensive highway problem. At least it is the advisory authority to which all branches of the state government turn. The commission and its engineering staff must take direct responsibility for the present highway situation. Judging from past experience, all future work should be subject at intervals to careful inspection and review of inspection by competent representatives of the people.

Reply of the State Highway Commission

In reply to the report of the Automobile Club of Southern California and the California State Automobile Association, criticising the construction and management of state highways, the California Highway Commission on Feb. 6 issued a statement in which the charges are discussed and answered. Excerpts from the statement follow.

Two major criticisms are made of the policies under which California has developed its highway system.

One of these has to do with the type of roads constructed in California, and particularly as to the width and the thickness of these roads.

The second has to do with the plan under which it is proposed to expend moneys remaining in the $40,000,000 bond issue.

The first criticism involves the question whether state highways should be built upon the unit plan, and widened, thickened, and surfaced as traffic increases, or whether the ultimate road, if such a thing exists, should be built as the first and original construction.

If the latter plan is adopted, it marks a complete departure from the policy under which California has developed a highway system that touches and serves almost every part of the state.

If the plan that the two auto clubs now advocate for California had been adopted when the state highway building started, highway construction in California would today be practically confined to the construction of a boulevard between a few large cities in the state.

Taking the first $18,000,000 bond issue as an example, if that entire bond issue had been expended in the manner advocated by the auto clubs, and construction confined to the minimum width of highway they advocate, namely, 20 ft., the whole amount of that bond issue could not have done more than build a highway from San Francisco to San Diego. The rest of the state would have been without paved highways as far as that issue is concerned. Graded and gravel roads could not have been built.

The increased costs under which the $15,000,000 bond issue was spent would have confined its expenditure to a few more boulevards. Rural counties and farming communities would be largely without good roads. The paved mileage in California would be less than half what it now is, with the added sacrifice of practically the entire mileage of graded and graveled roads.

Policy Under Which State Highway System Has Been Built.—Against this policy is that of the California Highway Commission, under which the state highway system of California has been built. This plan provides for the construction of a road of sufficient width and thickness to take care of existing traffic, with reasonable regard for traffic growth; it provides for a road so designed that it can be widened and thickened as traffic demands a heavier duty road without the loss of the original investment. Under this plan the old road is simply incorporated in and made a part of the wider and thicker highway.

On this point the biennial report of the Highway Commission

"This policy has resulted in giving to California a mileage in improved highways that could never have been built had roads been originally constructed to meet traffic demands of the far future, were it humanly possible to estimate either the extent or the character of such traffic. The added mileage thus secured has given to communities and counties all over California a good roads service, the value of which it is safe to say, runs into millons of dollars.

"Not only has this added mileage justified the commission's construction policy, but it is further justified by the fact that the alternative policy of building completed roads would have cost the state millions of dollars without due return. Huge hums would have been tied up for years in an investment which in large part would lie idle. The interest charge upon such idle investment would in itself amount to a huge sum.

"Added to all this is the undoubted fact that the good roads mileage built by the state has been the largest single factor in stimulating counties into campaigns for the improvement of local roads."

Future Traffic Demands.—It would be interesting to know just how the fact will be determined as to just what future traffic is to be, and what thickness and width of road it will be necessary to build to take care of such traffic. To quote from the report of the auto clubs:

"The number of automobiles in California has increased from 98,399 in 1913 to 535,000 in 1920. In the same interval trucks have increased from 5,299 to 35,000." Continuing the report says: "We may confidently expect a greater increase in the number of trucks. Their size, weight and future speed is an uncertain question."

The fact that the state highway system is taking care of this enormous expansion of traffic indicates the substantial character of its construction and that the roads were planned both with foresight and judgment.

The Highway Commission is willing to submit the issue to the business judgment of California as to whether it was better business to build a road for present traffic with reasonable regard for future development and capable of being widened and thickened as traffic demands, and thus to give the state the highway service it needed, or whether a few boulevards should have been built between large centers of population and the plan of building a system of roads that would serve the entire state thus abandoned.

Heavier Duty Trunk Roads Needed.—So much for past construction policies. The Highway Commission agrees with the auto clubs that the time has come when traffic demands a heavier duty trunk highway in California. Recognizing this the Highway Commission, before any question of the sufficiency of the highways was raised, by reason of the auto clubs' investigations, had already substantially increased its specifications. Much of the biennial report of the commission, submitted to Gov. Stephens early in January, is devoted to recommendations for widening, thickening and surfacing the older highways and for obtaining funds for this improvement through the medium of a gasoline tax.

The commission contends that this heavier duty highway can be secured without the loss of any appreciable part of that portion of the $36,000,000 that California has invested in its paved roads, if a continuous program of widening and thickening is carried on well in advance of permanent injury to the highway through intensive traffic. It is also the opinion that if such a program is started now, that this work can be carried on a "pay-as-you-go" plan, without future bond issues.

As to future construction, the auto clubs suggest a road from 6 to 8 in. in thickness, reinforced, of a minimum width of 20 ft. and 24 ft. wide near the large cities.

The specifications of the Highway Commission call for a 5-in. reinforced road, of a minimum width of 15 ft., but built wider where present traffic or the outlook for early traffic development demands a wider highway, and with the road designed so that it can be widened and thickened to meet future traffic demands.

Increased Cut of Wider and Thicker Pavements.—The commission is not adverse to increasing its minimum specifications. But the people of the state must understand that the construction of wider and thicker highways will cut enormously into mileage, just as the increase in specifications made by the commission from a 4 to a 5-in reinforced slab has cut into mileage.

If a further increase in minimum specifications is made, each community must understand that it means a reduction of mileage on its roads, and must be as willing to offer up its own mileage as it is to sacrifice that of its neighbor.

The only alternative is increased funds to give both mileage and added width and thickness.

Relative to the second major criticism, which concerns the plan under which the funds of the $40,000,000 bond issue are to be apportioned.

The report of the Automobile Association declares that the

California Highway Commission was [illegible] to aid gaps and to grading and paving all main [illegible] and to constructing what is described as "the [illegible] system" out of the funds made available by [illegible] lastly thirty-one additional roads were listed and added to the bond issue as desirable roads. As many of them were to be built as the balance of the funds would permit.

Attitude of Commission Relative to Budget Allotment.—The $40,000,000 [illegible] was made up by [illegible] certain roads. The sum of $20,000,000 was specifically set aside for completing what is generally known as the old roads and certain county laterals, upon which the state had previously agreed to share construction [illegible] with the counties. The [illegible] 000,000 was budgeted to certain new roads, which were specifically set forth [illegible] for construction in the [illegible] pledged was [illegible] to the formal drafting of [illegible]

The commission stands by the budget. It proposes to spend on every road as much as is in the budget for it. It does not propose to rob one road to build another. In fact, it is a question whether the law does not prohibit any other course; in any event it distinctly sets aside $20,000,000 for work on the original system and county-aid laterals, and by plain inference, allots the remaining $20,000,000 for new roads. Furthermore, the organizations which are now suggesting repudiation of this interpretation were the first to urge upon the commission the necessity of keeping inviolate the terms of the budget.

Since the attitude of the commission relative to budget allotment has been publicly announced, it has received approval from every section of the state for its fairness and sound public policy, and the commission has no intention of deviating from it.

The auto clubs practically propose to abandon the budget and to such an extent as may be necessary to throw the new roads overboard.

Do the people of California want this?

Financial Difficulties.—Criticism of a more minor character voiced in the report charges failure on the part of the commission to have a stated program for helping county highway departments; of slowness in paying bills; that the displeasure of the contractors has been incurred; of lack of experimentation, etc. The commission gladly gives advice to county highway departments and lends its engineering experience and force when such advice and assistance is requested. It does not believe that it is its duty to intrude itself into county highway affairs without invitation. It is not authorized in law, nor does it desire to assume any attitude of dictatorship in highway affairs in California. It is sincerely desirous of being of help to the counties and has been of such help on many occasions and in various ways.

Anyone knowing the financial situation that the Highway Commission has had to face in the last eighteen months who would criticise the commission for slowness in paying bills has little desire to be fair. It is a matter of common knowledge that the commission has been beset on every side. It had a number of going contracts on hand when the collapse of the bond market came. If these contracts had been shut down, damage suits for hundreds of thousands of dollars against the State would have resulted. Despite the financial difficulties in which the commission has found itself for the past eighteen months, bills have been paid in full, although not always on time and every contract has been kept going, and this without a single damage suit being instituted against the State.

As for contractors, it would be well for the people of California to take notice when contractors become too enamoured of the Highway Commission. There will always be some points of difference between contractors and the commission. The commission and the contractors, however, are working hand in hand to reduce these differences to a minimum. The commission desires contractors to make a reasonable profit, but it has insisted in the past and will insist in the future on the State's work being well done. This also is the desire of the great majority of responsible contractors.

Type of Pavement.—While complaining of lack of experimentation on the part of the commission, despite the fact that there are a number of different types of roads in the State highway system, it is noteworthy that the engineers of the auto clubs declare for cement concrete as a standard construction type. To quote from their report: "We believe that the most satisfactory type of pavement to stand heavy traffic conditions, particularly on insecure foundations, is an adequately and properly built concrete slab." The commission has adopted in California as its standard of construction a cement concrete base or slab built to meet traffic necessities. As funds are made available the commission believes this slab should be widened, thickened and finished with a wearing surface. Such a road, the commission believes, is the most practicable highway, both as regards the ability of the State to construct and as regards the service to be obtained from the road. The commission is not convinced, as the auto clubs appear to be, that the concrete road without a wearing surface is the final word

Wholesale Prices in January

The curve of commodity prices at wholesale showed a further decline in January, according to information collected by the Bureau of Labor Statistics of the U. S. Department of Labor in leading markets of the country. The Bureau's weighted index number, which includes 327 commodities, or series of quotations, and in computing which due allowance is made for the relative importance of the different commodities, dropped from 189 in December to 177 in January, a fall of about 6 1/3 per cent. The fall from the high peak of prices in May was approximately 35 per cent.

Building materials and house-furnishing goods showed the largest price recessions from the previous month, articles in the former group declining 10 per cent and in the latter group 18 per cent below the level for December. Farm products, food, and clothing each registered a drop of 5½ per cent or more, while fuel and lighting materials, metals, and chemicals each decreased more than 3 per cent compared with prices in the preceding month. In the group of miscellaneous commodities, including among others such important articles as cottonseed meal and oil, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, laundry starch, tobacco, Manila hemp, sisal, phosphate rock, and wood pulp, the decrease was 7 1/3 per cent.

Of the 327 commodities or price quotations included in the comparison for the two months, 188 showed a decrease, and 51 showed an increase. In 78 cases no change in price was recorded. Of these a majority belong in the groups of food and clothing.

Below are shown the index numbers of wholesale prices in the United States by groups of commodities, as computed by the Bureau of Labor Statistics for the months named. The figures for the last named month are preliminary and subject to revision. The base used in computing these index numbers is the average for the calendar year, 1913.

INDEX NUMBERS OF WHOLESALE PRICES, BY GROUPS OF COMMODITIES.

(1913 equals 100.)

	1920. January.	1920. December.	1921. January.
Farm products	246	144	136
Food, etc.	253	172	162
Cloths and clothing	350	220	208
Fuel and lighting	184	236	228
Metal and metal products	177	157	152
Building materials	268	266	239
Chemicals and drugs	189	188	182
House-furnishing goods	324	346	283
Miscellaneous	227	205	190
All commodities	248	189	177

Comparing prices in January with those of a year ago, as measured by changes in the index numbers, it is seen that food has declined 36 per cent, cloths and clothing over 40 per cent, and farm products over 44 per cent. In the remaining groups, except fuel and lighting materials, smaller declines have taken place, ranging from 3¾ per cent in the case of chemicals and drugs to 14 per cent in the case of metals and metal products, and 16⅓ per cent in the case of miscellaneous commodities. Fuel and lighting materials, on the contrary, were 24 per cent higher than in January, 1920. All commodities, taken in the aggregate, were 28½ per cent cheaper than in the corresponding month of last year.

Unemployment in England.—The percentage unemployed among trade unions making returns to the British Ministry of Labor was 6.1 at the end of December last, or greater than at the end of any year since 1909, according to The New Republic. The number of workers on the "live" registers of the employment exchanges rose from 520,000 at the end of November to 927,000 on January 14th. In addition, there is wide-spread short-time; not less than 446,400 persons (and probably a good many more) were working four days or less per week at the same date.

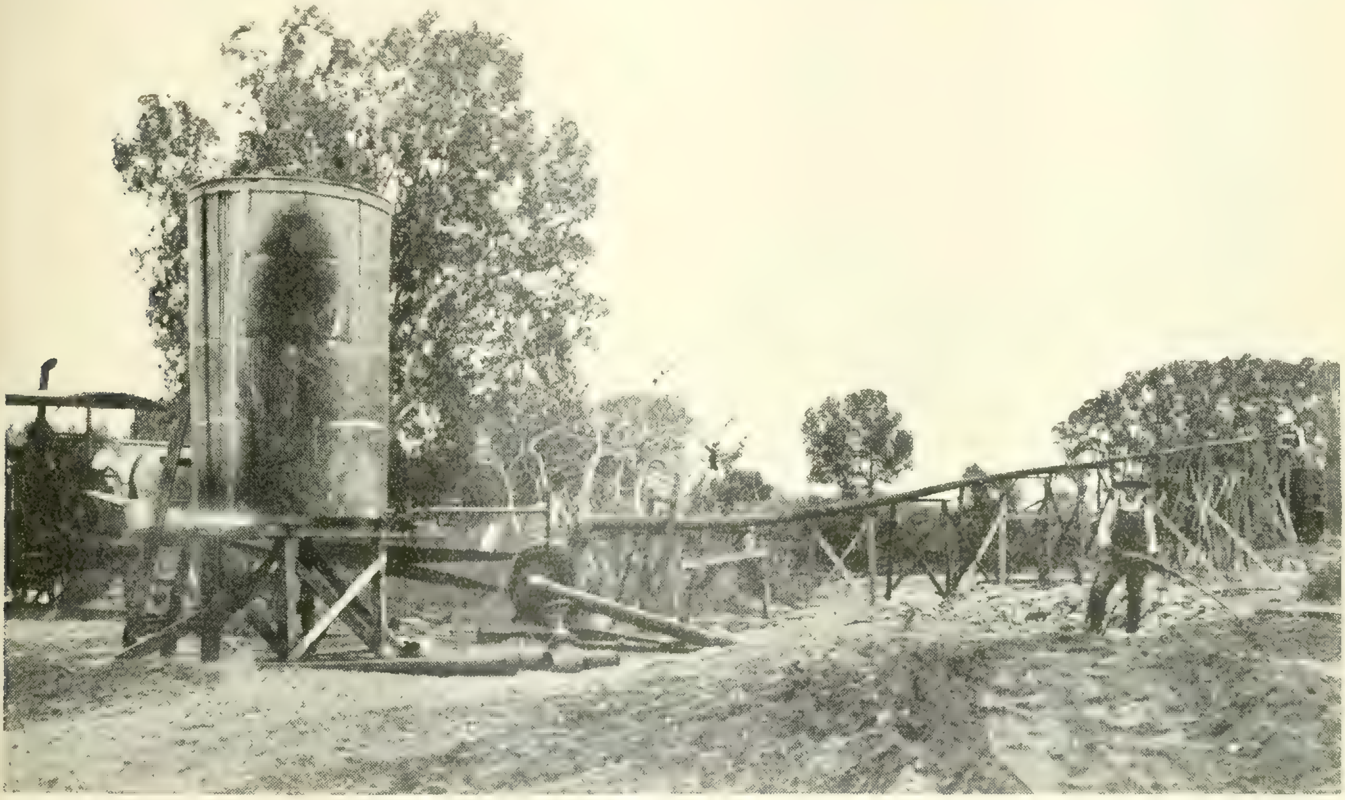
Road Grading Gang Housed in Culvert.—Following the rains in October a road grading gang on the Beaver City-Arapahoe Federal Aid Road project in Nebraska boarded up the ends of an 8 by 8 by 28-ft. box culvert, furnsihed it for living and cooking quarters, and then proceeded to surround their home with 6,000 yd. of fill. Their gamble with the rain was successful and six men lived very comfortably in this box for a month and a half, when they had all of the nearby excavation completed.

Aggregates for Concrete Road Job Supplied by Hydraulic Plant

To supply sand and pebbles for the concrete pavement on Federal Aid Project No. 82, between Denver and Morrison, Colo., an aggregate plant has been built in which the materials are lifted from a dry creek bed with a centrifugal pump and forced through a pipe line to the screens. The arrangement is described in the January-February issue of the Concrete Highway magazine.

The plant is located on the banks of Bear Creek, approximately 1 miles south of Midway, Colorado, and immediately adjoining the main road connection the Denver-Morrison and the Fort Logan-Morrison Highways.

Gravel from a dry bed in Bear Creek is "slipped" with teams to a 2 by 3 ft. grizzly with 2½ in. openings. The grizzly is set in the floor of a wooden platform slightly raised above the general ground level. Materials smaller than 2½ in. drop through the grizzly into a sump. To facilitate the passing of the aggregate through the grizzly a stream of water from a 2 in. hose is flushed over them. The water supply for this purpose is obtained from the overflow from the sand box on the screening plant. Oversize material rejected by the grizzly is thrown to one side with a shovel.



Pumping End of Aggregate Plant on Denver-Morrison Road Project.

The material is lifted from the dump through 18 ft. of 6 in. pipe lying at an angle of approximately 30 degrees to an elevation of 8 ft. by means of a No. 5 Byron and Jackson manganese steel lined centrifugal pump especially designed for this purpose. The pump is belted to a 65 H. P. tractor. The sump at the end of the intake pipe is a wooden box below ground water level, with a 2½ in. grating over its top. From the pump the materials pass through 300 ft. of 6 in. pipe to the top of the screens over the aggregate bins. The discharge is about 33 ft. higher than the intake.

There are only two elbows in the pipe line, one connecting the intake line to the pump and the other connecting the pump to the discharge line. Short pieces of steel lined hose were first used for elbows, but these had to be replaced every 2 or 3 days because of wear. The steel elbows subsequently installed rendered efficient service and no replacement was necessary during a period of approximately 3 months.

At the point of discharge the aggregate drop on a sloping screen of ¼-in. mesh, through which the water and the sand pass into a 6 by 6 by 4-ft. sand settling box with sloping bottom. A 4-in. overflow pipe at the top of this box carries away the dirty water and all impurities. When the box is full a gate near the bottom is opened and the sand discharges into a 14 by 14 by 10-ft. bin directly underneath.

The coarse aggregate passes over the ¼-in. mesh screen onto a 2-in. screen, through which it drops into a 14 by 7½ by 10-ft. bin. The oversize rejected by the 2-in. screen rolls over the end of the bin to a waste pile on the ground. Trucks are loaded through sliding gates and chutes located in the sides near the bottom of the bins.

The amount of material pumped into the bins varies with the amount that can be moved from the gravel bed into the sump. The average output of from 60 to 80 cu. yd. per 8-hour day does not represent the capacity of the pump but is determined by the amount of material that can be brought to the sump, and the speed with which the aggregates were hauled from the bins to the job. The output secured was sufficient to meet the needs of the job and the size of the contract did not warrant the installation of more elaborate equipment. Operating continuously, it is estimated that a maximum of 125 cu. yd. of aggregate could be turned out in an 8-hour day by this equipment.

The necessity for washing the available material prompted the contractors, the Colorado Bridge & Construction Co., of Denver, to erect the plant with equipment which was already at hand. An excellent quality of clean, well graded aggregates was secured, contributing materially to the construction of a first class concrete pavement.

Highway Conference at Ames, Ia.—The 8th annual conference of Iowa road officials will be held at Ames, Ia., March 23-25. County engineers and assistants, supervisors and auditors and township officials, including clerks, trustees and road superintendents, have been invited to participate in the conference. At last year's conference there was an attendance of 450. A larger number is expected to be present at the 1921 meeting.

Pennsylvania May Pay Higher Interest on Road Bonds.—Governor Sproul of Pennsylvania on Feb. 22 approved a bill passed by the legislature increasing the maximum interest the state may pay for state road bonds from 4½ per cent to 6 per cent. The bill was introduced as a result of the failure of the state to receive any bids last summer for $11,800,000 worth of the $50,000,000 road bond issue, then offered for sale.

Financing Highway Improvements

In an address delivered Feb. 11 at the 18th annual convention of the American Road Builders' Association, Mr. Horace C. Sylvester, Jr., vice president of the National City Co., New York City, outlined the general principles of highway finance as viewed by a banker. We quote as follows from his address:

Until permanence in highway construction has been attained, the financing of the work should be effected with due recognition of the possibility that re-construction may soon be necessary.

The first principle which I would emphasize is that in financing highway construction, money borrowed should be repaid as soon as the principal and interest can be raised by taxation, without unreasonably burdening or oppressing the taxpayer. Under present conditions, it is impossible to forecast the time when re-construction and re-building will be required. Before that time arrives, the bonds or obligations issued to finance the original construction should have been retired.

It is frequently urged that bonds for public improvements should not run beyond the probable life of the improvement. In my opinion, this idea has only a limited application to the financing of highway improvements. Highway bonds should not run during the probable life of the improvement, if the municipality, county or district can sooner retire them. If it retires them at the earliest possible date, it clears the field for the reconstruction which under present conditions appears to be inevitable.

On the other hand, if the improvement is of such pressing necessity that the locality cannot prosper without it, the fact that the term of the bonds will exceed the probable life of the improvement, should not prevent construction if the securities can be retired within a reasonable term. It is my opinion that no highway bond should run longer than 30 years. If the locality cannot pay sufficient taxes to retire a highway debt within 30 years, there is grave question whether the highway should be undertaken. Any improvement may cost more than the municipality ought to pay, and that point in my judgment is usually reached in the case of highway construction when a county, township or district cannot pay the debt within the term of 30 years. Minds may differ as to the maximum term. Some might say that 40 years is not too long. Whatever the maximum term be, every one will agree that some limit should be placed upon the life of the debt.

The State in Highway Financing.- The other features in the proper and successful financing of highway construction are those which create an attractive and marketable security and permit the borrowing of money on the cheapest and lowest terms. The price paid for money is the interest or interest and discount, if bonds are sold below par. The successful security is that which can be issued at or close to par at a low rate of interest. The method of financing should be directed to the issuing of such a security.

The first consideration is that the larger and wealthier the obligant in the bond, the better the price which will be received. If highway construction can be financed by state bonds, the money will be borrowed at a lower rate than if it is financed by county, township or district bonds. Road builders now recognize that it is the function of the state to provide a state-wide system of highways. For the construction of these, state bonds are usually issued, and bear a lower rate of interest than any other form of highway obligation.

County Bonds Attractive to Investors.—The next unit in road construction in order of importance, is the county. County bonds approach the state bonds in security and desirability, and are a much better security and much more attractive to investors than the bonds of a township or district.

Finally come the bonds of the township or district. These are good securities, but the rate of interest is higher than the rate on bonds which may be issued by either the county or the state.

To successfully finance highway construction, it is my opinion that highway bonds should be issued by a state, by a county, or by a district or township, and should be paid from an ad valorem tax which is authorized to be levied in an amount sufficient to pay the bonds. No limit should be placed upon the rate of tax which may be levied. If such a limit be imposed, the desirability of the security will be affected, the rate of interest will be increased, and the taxpayers will be needlessly burdened.

Community Credit a Valuable Asset.—The day has gone when the citizens of any community will borrow money for a public improvement and stand by and condone a default in repayment. The public is slowly but steadily recognizing that the credit of the community is a valuable asset; that it means modern improvements, and the many facilities and advantages which are now furnished through the agency of municipalities and political subdivisions and which are so essential to modern life. If the municipality or political subdivision defaults in its obligations, its credit is destroyed; it can no longer raise the money with which to furnish the citizens with modern advantages, and its residents soon find that they dwell in a locality upon which a blight has fallen.

In addition, there is the inherent principle of honesty in the repayment of a debt, and to the credit of American communities, it may be said, that few or none, take money from a lender and refuse repayment. Hence, no matter what tax may be provided for the payment of the bonds, whether it be limited or unlimited, the community intends and expects to repay, and the imposition of a tax limit for the purpose of repaying the debt merely causes the municipality or political subdivision to pay a higher price for the money it borrows. Self-interest thus demands that the state and its subdivisions should place behind the bonds, an unlimited power to raise sufficient taxes to pay principal and interest.

How Investors View "Special Assessments."—The same principles apply to all special forms of highway securities, such as those authorized by the Donahue Act of Washington or the Covert Act of Michigan. Each of these statutes embodies the idea of a special assessment. While a security based upon a special assessment may be marketable, the price paid in the shape of interest and discount, will be much greater than in the case of an obligation secured by an ad valorem tax. This will be the case where the bond is issued by a county but is payable from a special assessment, and it is only when a default has taken place in the collection of a special assessment, that the county can be compelled to pay principal or interest. Such an obligation is not regarded with favor. A bond of this kind is usually issued because of some constitutional requirement, or because of the financial condition of the county, in relation to the limitations upon its power to contract debt. Investors do not regard it with the same favor as a direct promise by the county to pay from a tax to be collected by it.

Usually, too, no substantial reason exists for the issuance of a bond payable from an assessment, and upon which the county is only liable in the event of a default in the assessment. The county seeks to sell such a bond as its general obligation and looks for the same price as it will receive for a courthouse bond running for the same term and bearing the same rate of interest for which no other means of payment exists than a straight levy of taxes. If the county wishes to obtain the best terms possible, it should when so authorized, issue its own obligations and promise to levy a sufficient tax to pay them. If the improvement is a proper case for a special assessment against abutting property, or even against the township or district, such special assessment should be treated simply as a means of reimbursing the county, with which the borrower will have no direct concern. The special assessment should be regarded simply as in the nature of an additional means of raising money or more equitably distributing the public burden and should not have any relation to the bond or debt, except such as arises from the fact that the county has an additional resource.

The county differs only from the city in that it is rural whilst the city is urban. It may, if authorized by statute, collect special assessments for road improvements, just as a city may levy and collect special assessments for street improvements. The best street improvement bond is one which the city promises absolutely to pay from a levy of taxes, although it may also have power of making a special assessment to reimburse it for the cost of the improvement. Many city paving bonds are so issued, and there is no reason why the county should not adopt the same method of issuing its road securities as the city does in issuing its paving bonds.

Refunding Issues Expensive.—Simultaneously with the issuing of bonds, the authorities should decide in what method the debt will be paid. In former years, the general method was by issuing a bond having a flat term of say 20, 30 or 40 years, and providing for the raising of a sinking fund for the payment of the principal. The obligation to create a sinking fund was not usually observed, and when the bonds matured, it was frequently, if not generally, found necessary to issue a refunding obligation. The same situation might exist when the refunding bonds matured and a second refunding found necessary. Three refundings each for 20 years, of an original issue of bonds which ran for a term of 20 years, have been known to happen. The bonds so issued in effect ran 80 years, and although it was the duty of the municipality to annually raise money by taxation to create a sinking fund at three maturities no sinking fund existed. The interest rate has fallen during the past 60 or more years covering the life of the original bonds, and the first two refundings of this particular issue. It is probable that an average rate exceeding 5 per cent per annum has been paid on these bonds. More than 300 per cent of the original loan has already been paid by way of interest, and by the time the present refunding reaches maturity, the amount of this interest will be 400 per cent of the original loan. This is not sound financing.

Serial Bonds Replacing the Flat Term.—To provide against such a situation, what are known as "serial" bonds are now more generally issued than flat term bonds. In a straight serial issue, a fractional part of the bonds matures in each year, commencing one year after the date of the bonds. The amount of principal payable in each year is the same. The result is that if the loan be for $100,000 at 5 per cent, running over a term of 20 years, the first year's payment for the instalment of principal and the interest on the whole loan will be $10,000; the last year's payment, being the instalment maturing that year, with interest on that instalment, being the balance of the loan which is outstanding, will amount to $5,250. During the life of this loan it is probable that the wealth and resources of the territory will increase and the tax burden for the payment of the principal and interest would be much easier borne during the last years of the loan than during the first. Such considerations suggest that some other scheme of maturities is desirable.

The ideal method is probably to so arrange the maturities that a similar amount will be payable in each year during the life of the loan for principal and interest, but it is not always expedient to break up the number of bonds maturing each year into uneven amounts, as the market is to some extent affected thereby. Consequently, the best course would seem to be to require a serial bond to be issued, but to permit the governing authorities some discretion as to the amount which shall mature in each year, as by providing that the loan shall be payable in annual instalments, commencing one year after date, but that no instalment shall be more than three or four times the amount of any other instalment.

Arranging of Maturity Dates.—Sometimes the first maturity is postponed. A postponement of the first maturity for a period not exceeding two years is reasonable, because it sometimes happens that no tax can be levied in time for the payment of the principal of a bond maturing one year after date. For instance, the taxes for the year 1920 might just have been levied at the time when the bonds were issued, but might not be payable until 60 or 90 days thereafter. If the bonds were payable one year after date of issue, the first instalment would be payable before the 1921 levy, with the result that no provision would have been made to raise by taxation the amount payable one year after the date of the bonds. For this reason, it is probably better that the instalments should begin to mature not later than two years after the date of the bonds, and the date of maturity should be so fixed in relation to the collection of taxes as to permit the payment of the principal at the earliest date thereafter for the purpose of saving interest to the county, district or township during the time which will elapse in each year between the collection of taxes and the date when an instalment of principal becomes payable.

Sometimes the first maturities are postponed beyond two years, but I have pointed out that permanence in highway construction has not yet been reached, and it is my opinion that highway bonds should begin to mature and should be paid off as quickly as possible, and that the first instalment should not be postponed longer than is necessary to permit the proper financing of the project.

Advantages of Serial Maturities.—The advantages of a serial issue as compared with a flat term issue are numerous. The serial issue immediately absorbs the monies raised by taxation to pay the principal. The creation of a sinking fund is rendered unnecessary. The accumulation of large sums in the city treasury in the name of a sinking fund, possibly bearing a small rate of interest, whilst full interest is payable on the city's debt, is avoided. The serial issue automatically conforms to the principles of economic financing, and even if compared to cases when the sinking fund is efficiently administered, results in a saving to the municipality.

The serial method by dispensing with a sinking fund avoids the danger of loss from improvident or negligent management of sinking fund monies, or from dishonesty or incompetency. It removes the temptation to so employ large sums of money as to further personal rather than public aims, and if consistently carried out, it avoids incurring the expenses for the management of a sinking fund.

But a further and much greater advantage rests in the fact that if a serial issue be made, the danger of a refunding at maturity will be avoided. In the state of California, the serial method has been in use for upwards of 30 years, and in my experience I have never handled an issue of refunding bonds of any city, county or school district in California. A well-known bond attorney, who examines many California issues, has told me that he has never had an issue of refunding bonds of any city, county or school district in California submitted to him for examination. These facts demonstrate the effectiveness of the serial plan when consistently adhered to.

Proper State Laws Imperative.—I have discussed the best method of financing highway improvements from the ideal standpoint, and have assumed that the legislature has dealt generously and liberally with counties, districts and townships. If the necessary powers to issue bonds, such as I have described, do not exist, they should be asked for, and I believe that the legislature will not hesitate to grant them, if it can be done within the limits of constitutional restrictions.

Constitutional restrictions sometimes compel resort to other methods. For instance, if there be a constitutional limit of indebtedness, and the counties, townships or districts in a state have become generally indebted to an amount approximating the constitutional limit, resort must of necessity be had to an unusual and less desirable type of security to finance highway improvement. Resort must be had to special assessments for benefits payable in annual instalments, extending over a term of years, and to the issuance of bonds which are payable only from such special assessments. The courts have held that when a special fund for the payment of a bond is so created, and the obligation of the county, township or district is limited to the collection of the assessment and its application in payment of the obligation, and there is no recourse over and against the general property or funds of the obligant, no debt is created within the meaning of the constitutional prohibition.

But these obligations are not acceptable in the market. They can only be placed if they bear a high rate of interest, and, many times, they must be sold at a discount. Frequently they are issued directly to contractors, who have bid for the work, knowing that they must take payment in this form. The cost of the improvement is increased, because the contractor so bidding will add enough to absorb any discount at which he will be obliged to sell the bonds. The price of money necessary to finance an improvement when raised in this way will be great. When money may be borrowed upon a general obligation of a county at, say, 5 per cent per annum, it will be found necessary to pay 6 per cent upon a special assessment obligation at the least. Sometimes the special assessment obligations will be disposed of to the ultimate investor so as to net him 7, 8 or 9 per cent per annum. The public must pay this return to the investor in some form or another.

Keep the Buyer of Securities in Mind.—In financing your road improvements, I urge upon you always to try to issue a security which will be attractive to the investor. It is good business for the county, township or district. It is also good business for the banker. The certainty of payment on the due date of an obligation is of the essence of all successful business and everything that can be done to assure the investor that on the day stated, the amount of his loan will be repaid to him, will tend to reduce the cost of the loan to the borrower.

When the type of security and all the particulars as to rate of interest, date of maturity, etc., have been fixed, the bonds should be offered to the public under conditions which will assure the quickest possible delivery. It is usual to require the examination of a municipal or county obligation by a recognized bond attorney before it is accepted by the purchaser. The best practice is to have this step taken and the opinion secured before the bonds are offered for sale. If that be done, then substantially immediate delivery is assured, and the risk or probability of fluctuations in the market is reduced to a minimum.

Negotiating the Sale.—The sale should be conducted under such terms as will assure a fair deal. If a public sale be had the bids should be received, opened, and the bonds promptly awarded under conditions which will exclude the possibility of favoritism. If the bonds be sold privately, the negotiations should be so conducted that when the purchaser takes delivery of the bonds, he will not find that the county, township or district has already offered them indiscriminately to all the banking houses and generally shopped around trying to obtain a purchaser. No person likes shop-worn goods, and bonds which have been privately offered to every banker or investment dealer by some person professing to act on behalf of the county, township or district, are not looked upon with favor by reputable dealers.

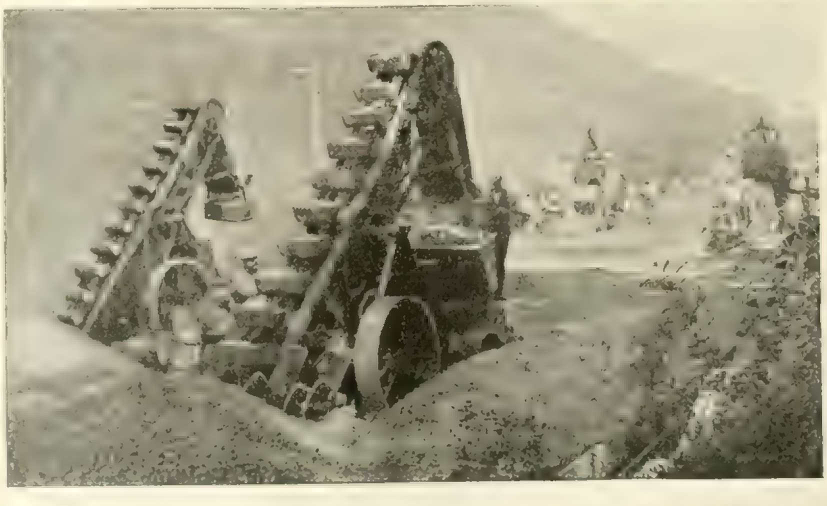
In everything that is done, the best policy is to place the interests of the county, township or district first. Reputable bankers and dealers wish a security which is beyond suspicion and prefer dealing that is open and above-board, and so long as they are squarely treated in the sale of bonds, no reputable banker or dealer will complain merely because the interests of the public are carefully protected.

Handling Aggregate With Wagon Loaders and Tructractors

Several new methods of material handling in road construction were put in service during the past season. A good example of one of these methods is shown in the accompanying illustration of a section on the new Bronx Parkway, now under construction from the northern end of Bronx Park in New York City, to the Kensico Reservoir at Valhalla, in Westchester County, New York, a total length of 16 miles.

The road contractor is the Hastings Pavement Co. About one mile from the construction work the contractor obtains the necessary sand. This material is automatically loaded into a number of auto trucks by means of a Haiss "Path Digging" wagon loader. Two similar type loaders may be seen in the illustration operating on the new road; one digs sand and fills a measuring box, and, on the opposite side, the other digs crushed stone, also filling a measuring hopper. Beyond the loaders are two Foote concrete mixers, and running between these two sets of labor saving machinery are three Clark tructractors.

The sand and stone piles, dumped along either side of the road, are of such amounts that when they are dug away, a clear space, averaging 50 ft., is always maintained between the sand loader and the line of mixers, while on the other side a space of 75 ft. is left open. By this arrangement the tructractors, after receiving their measure of sand, avoid getting into each other's way when they steer over to the stone loader. Filled with material, the tructractor then shoots up to the first concrete mixer waiting with its power loader down for a fresh charge. At the same moment that the tructractor dump-body discharges, a laborer empties a bag of cement in with the dry aggregate, and almost the next instant this material is sliding from the uplifted charging scoop into the revolving mixing barrel, and finally, the wet mix drops from the end of a long swivel spout to the road.



Wagon Loaders and Tructractor on Construction of New Bronx Parkway.

The observed speed of each tructractor was 1 minute for a round trip with ½ cu. yd. of material. Therefore the three tructractors deliver 1½ cu. yd. in 1 minute to the two concrete mixers, an average of ¾ cu. yd. in 1 minute to each mixer. The number of laborers actually required was three for the two loaders, three for the three tructractors, two cement men, and ten men for the two mixer gangs; thus making a total of 18 laborers.

Drainage Systems for Different Subgrade Conditions

Conclusions on the design of highway drainage systems based on experience and actual conditions as found in the state of Maryland, were summarized by H. D. Williar, Jr., assistant chief engineer, Maryland State Roads Commission, in a paper presented Feb. 7, at the Conference on Highway Engineering at the University of Pennsylvania. An abstract of the paper follows:

The greatest detriment to a perfect sub-base is water. Its presence will ruin any road—the wearing surface regardless of what it is—cannot save it. Where there is water in the foundation a failure in the surface is inevitable. Therefore, the first point to be considered in the design of a road is in what manner does water affect it? These ways will be discussed under two heads: (1) Surface Water; (2) Ground Water.

Surface Water.—The time when water does the greatest damage to a road is during the early spring thaws and during and immediately after a heavy, washing downpour of rain. If a road "stands up" satisfactorily through these two periods, its life is reasonably assured. Maryland has adopted a plan that has reduced bad washes to a minimum. It is conceded tht the greatest "wash outs" after a hard rain occur on fills just at the end of the cut. A great volume of water accumulates and increases in velocity in the confines of the cut; it suddenly reaches the end of the banks and gushes down over the fill, cutting out ravines from the edge of the road metal to the toe of the slope. Frequently, the roadway itself is completely undermined. These washes occur more frequently on new fills, but all fills are "green" once and it is then that they should be protected. In the opinion of the writer it is an excellent policy to construct a wooden funnel shaped trough at the juncture of the cut and fill. This should be connected up with a wooden chute at right angles to the road running down over the entire depth of the fill and terminating in the bottom at a point to clear the toe of the slope. Such construction may economically be made of ordinary 2 by 12 in. lumber and should be placed as frequently along the fill as the composition of the material in the fill and grade of the road demands. It is recommended, however, that one at least be located at the beginning of the fill and one at the low point if there be one. These several funneled inlets should be connected by a strip of 12-in. lumber pegged along the top edge of the fill to form a curb and gutter.

In some sections of Maryland, the western and central parts particularly, natural drainage conditions are excellent and the use of any form of artificial drainages is unnecessary. In the lower counties of the Eastern Shore, however, drainage conditions are diametrically the opposite. This is the tide-water section of the state, where grades are literally flat and the soil notoriously impervious, being mostly "white oak" clay. In this part of the state, road building presents quite a series of drainage problems—the one and only solution to most of them is the side ditch. It is most essential that the water table be kept at least 1½ or 2 ft. below the metal surface of the road at all times and while open ditches are admittedly dangerous to traffic and their upkeep expensive, their use especially in flat country has proven them to be the only effective means of drainage and are therefore highly recommended.

Most of these ditches are built from 1½ to 2 ft. below the old ground, 18 in. across the bottom and parallel to the road. The inner slope (next to the road) is on a 1:4 grade and the outer slope on a 1:1 and the material from these ditches is invariably used to elevate the road itself and help to lift it out of the water. Most of these roads have been built on nearly dead level grades. The best that could be hoped for to drain them was the ordinary farm ditch, miles of which exist and function on 1/10 of 1 per cent grades and into which tide-water backs periodically. Under such conditions as these, there has been constructed and perfectly maintained 500 miles of modern highways.

Ground Water.—Under this heading will be considered the water affecting the road opposite from direct rain fall. For instance, springs, side seepage or vertical and horizontal capillary. It is the opinion of the writer that a number of the states are spending too much money preparing for extreme conditions. He believes it bad practice from an economical viewpoint to almost promiscuously build miles of drainage for ground water just to be on the "safe side". It is a fact that there are many dollars of public money spent annually on just such construction when this money plus the interest would far more than pay for an occasional failure. By this, the writer means, when a condition presents itself where without question some form of sub-drainage is necessary, construct it, but he means further that if there is doubt as to the advisability of underdraining a particular stretch of road, do not waste time and money to do it. Sub-drainage is either needed or it is not, and it is believed that far more of it is used than is necessary.

Maryland is fortunate in its geological composition in that it requires comparatively little sub-drainage in the construction of highways. There are, however, isolated places in the state where the sub-grade condition makes it necessary to provide a system of sub-drainage, in addition to the drainage for storm water; places where drains must be provided to lower the level of the ground water under the road. The elevation to which ground water rises depends on the capillary power of the soil and on the hydrostatic pressure to which this water is subjected. If ground water is present to any extent and the soil such as to permit it to rise to within several feet of the sub-base, the stability of the roadbed is in danger and unless some adequate sub-drainage is provided, failure in the final construction is inevitable. The common methods of drainage to prevent such failures are (1) tile drains, (2) French drains, (3) V-drains. The open ditch as previously described should also come under the head of "ground water". It functions well for either or both classes of water.

Tile drains are usually located immediately under one edge of the road surface although conditions may be such as to require two lines of tile, in which case they should be constructed one along each edge of the metal. A road going through a deep cut where there are numerous spring heads in the banks frequently calls for such a system of drainage; and for such cases, the following design is advocated: The underdrain should consist of 4 in. vitrified clay pipe laid on a 2 in. layer of 1 in. stone in a trench 12 in. at the bottom with flaring sides. The joints of the new pipe should be open but covered with tar paper and the trench filled with 3 in. stone for an additional depth of 22 in.

The French drain varies from the tile drain in one respect —it is a trench filled with large stone, but without the vitrified clay pipe.

The V-drain form of drainage is adaptable to localities where field stone can be obtained in abundance. It consists in digging out the sub-base of the road to an additional depth of 12 in. in the center and 4 in. on the sides and back-filling this V-trough with stone or gravel. This type of drain if properly constructed and provided with side outlets every 50 ft. may prove advantageous. Its efficiency will be increased by placing a line of small vitrified clay pipe down the center.

Under Maryland's 1,700 miles of improved and well maintained highways there is less than 3,000 in. of "V" drain, less than 5,000 ft. of French drain and less than 30 miles of tile drain.

Preparation of Estimates of Cost of Construction

Useful suggestions on the preparation of estimates was given by Warren W. Mack, Assistant Engineer, Delaware State Highway Department, in a paper presented Feb. 8 at the Highway Engineering Conference at the University of Pennsylvania. His paper practically in full follows:

An estimate prepared industriously, honestly and systematically will seldom be so far afield as to invite severe criticism. Industry is emphasized because much patient effort is required to secure the information necessary for the preparation of an intelligent estimate. Honesty is essential, for an estimate must be prepared without bias or prejudice; the temptation to "cut the garment to fit the cloth," to allow one's optimism to run away with one's judgment, or to yield to the occasional importunities of superiors, must be constantly resisted. An engineer's estimate should represent his honest beliefs. If there must be a day of reckoning let it come before the contract is let, rather than after the final settlement. Estimates should be made systematically, for without a well thought out system, many small items bulking large in the total may be omitted.

The engineer's preliminary estimate is frequently a curious striving after the impossible, viz.: an estimate that will not be so low that the opening of the bids will bring discredit upon the engineer, yet one that will not be so high as to discourage or prohibit entirely the carrying out of the project. An estimate of this character is peculiarly like the aim of the old settler "to kill if it is a bear and to miss if it is the heifer."

In the past engineer's estimates have had a reputation for inaccuracy, frequently falling far short of the final cost of construction, a condition embarrassing alike to the engineer, his clients and the contractor. It is generally conceded that there has been an improvement in recent years and that an increasing knowledge of costs and a fuller realization of the importance of careful estimating has been evident in more uniform and more consistent estimates.

Factors in Preparation of Estimate.—On what shall the engineer base his estimate? On his personal knowledge of costs, on prices bid on similar work, or shall he call in an experienced contractor and secure from him a preliminary estimate? In these latter days it is too much to expect an engineer to predict with certainty the cost of construction. The changing prices of labor and materials, the shortages of both materials and transportation, have made estimating more of a gamble than ever.

However, every highway engineer should have available cost data that he has personally compiled as well as published data. Placing greatest confidence in his own collected costs, next in that of work with which he is familiar, and using as a check published data, the recorded experience of others. He should secure current market prices of all materials used in highway and bridge construction, as well as freight rates from all probable points of shipment to the possible points of delivery on the proposed work.

A careful survey should be made of the local material supply; in order to be of value this information must be quite definite, both as to quality and quantity of materials available. If there are local pits and quarries already developed, this information may be easily and accurately obtained, but if the contractor must open and develop the local supplies, it is easy to under-estimate the cost of development. This is one of the common errors in estimating, made by both engineers and contractors. Contractors often spend considerable money in development only to find the material is not up to specifications or is insufficient in quantity, and the development work almost a total loss.

Local transportation conditions should also be studied, especially the length of haul from railroad sidings and the grades and the condition of the roads over which materials must be hauled. In short, a detailed study should be made of the entire job, especially as to its accessibility, the best methods of executing the work and its peculiar opportunities for profit or loss. A careful study of the plans and profile will yield much valuable information if it is supplemented with an equally careful inspection in the field covering the nature of the soil, availability of the water supply, opportunities for using grading machinery, possible borrow pits, etc.

Besides the large and constantly increasing cost of plant required by the road contractor, a large outlay is necessary getting the equipment on the ground, erected and ready for operation. This with attendant delays before any work is done which appears on the progress estimate, places a heavy strain on the contractor's resources. Due allowance should be made for plant rental and depreciation, cost of contractor's bond, and employer's liability insurance, as well as for labor and the manipulation of materials.

Superintendence and general overhead expenses are frequently minimized by engineers, who also often leave out the important item of profit, which certainly should not be forgotten, even though an agreement as to the amount may be difficult.

Few engineers can be expected to have a comprehensive knowledge of all these factors, which, however, should ever be borne in mind and at least approximated, for here as in many other cases, an approximate answer is better than no answer at all. Even with every item considered there is much left to judgment, and in the past few years much has of necessity been left to chance.

Securing preliminary bids from reliable contractors is a practice very generally followed by architects. This method has the advantage of securing the judgment of men who specialize in particular lines and whose advice in suggesting means of reducing the cost of expensive construction is especially valuable. It is probably not so generally applicable to highway as to building construction, yet we believe it can be frequently used to advantage. Every engineer knows certain contracts in whose judgment and fairness he has confidence. He can gain much valuable information and advice from such a counselor.

Possibly under preesnt conditions, an intelligent use of recent bidding prices with due consideration of local conditions will give us as reliable results as can be hoped for until conditions are more settled. In using previous bidding prices it must be borne in mind, however, that prices may be unbalanced; that the low bid is often too low; and that there may be radical differences in the specifications or the interpretation of them.

Accurate Estimate of Quantities Should Be Given.—One thing the contractor may reasonably expect from the engineer is an accurate and complete estimate of the quantities contained in the proposal. Failure to furnish an accurate estimate will mislead the contractor and may cause him material loss, as the increasing or decreasing of any item by a considerable amount may greatly change the unit cost, a fact the average engineer is usually quite loath to admit. Reasonable allowance should be made for all bridge, culvert and pipe excavations, as well as for ditching, items not usually large but totaling a considerable amount and frequently omitted entirely.

Earthwork is usually an important item in highway work. While the engineer's estimate usually shows the number of cubic yards of material to be moved, the length of haul is seldom given, nor does it show the number of square yards of trimming or "sand papering," as our contractor friends love to call it, which will be necessary to finish the work. This is frequently an important item, especially if the work is light.

Systematic borings of all materials to be excavated, whether in excavating for the roadway or in foundations for structures, would give information absolutely essential to an intelligent estimate. This practice has long been recommended by practical engineers, but seems to be gaining but little in popularity. It is conceded to be a good idea to carry out at some future time—not now. Many instances could be given where the neglect to make borings has resulted in a serious loss either to the contractor or the state.

There is sufficient opportunity for the exercise of judgment when full information is at hand, without gambling on the classification of materials a few feet under ground. It appears to the writer that the arguments put forward for the non-classification of excavated materials are hardly convincing.

Why Engineers Under-Estimate.—The cause of frequent under-estimating by engineers has been analyzed by Mr. Halbert P. Gillett in his book "Earthwork and Its Cost," as follows:

1. Failure to train engineering students in the art of cost estimation.
2. Dearth of published cost data.
3. Failure to ascertain by test pits or borings what kind of material will be encountered.
4. Failure to ascertain just where structural materials will be obtained and their exact cost laid down at the works.
5. Failure to consider the fact that changes in alignment or design made after beginning work may increase first cost, though desirable.
6. Failure to allow for the rise in wages and price of materials consequent on the increased demand, generated by the construction work itself, if large.
7. Failure to recognize the fact that high wages breed an "independence" among workmen that results in decreased efficiency.
8. Failure to recognize the fact that a large number of competent foremen is difficult to obtain for large and extended works, resulting in a loss of efficiency.
9. Use of unit prices taken from other contracts of similar nature, without considering that bids may have been unbalanced, or if not unbalanced that the lowest bidder lost money on the work, or that the conditions of work are not exactly similar.
10. Failure to add anything for plant rental and depreciation, also cost of moving plant and lost time.
11. Failure to make allowance for general expenses, such as road building, office expense and foreman expense borne by the contractor.
12. Failure to allow for cost of handling water, snow and ice, and to consider the cost of accidents and delays resulting from bad weather, etc.
13. Failure to add a reasonable margin of profits, or to consider that where 15 per cent for profit on materials may be paid, 25 per cent profit on labor is often too low because of the uncertain efficiency of labor.
14. Failure to recognize the fact that contractors may abandon a contract, causing delays in completion with consequent added cost besides the legal expense.
15. Finally the fixing of unit prices in the cost estimate before the specifications have been drawn.

Mr. Gillette has analyzed this problem very completely, and has shown that the error lies in failing to systematically analyze and estimate each item of cost.

An example of the failure to systematically prepare an estimate was recently brought to our attention. This estimate was prepared jointly by an engineer and contractor and was prepared for the purpose of comparing the cost of a local sand, which required the opening of a pit, the washing of the sand and its final delivery to the mixer, with a commercial sand delivered at the same point. A more or less informal estimate placed the cost at $1.00 per ton. A later estimate in which each step in the excavation, handling, washing and trucking, was systematically estimated, increased the estimate to over $2.00 per ton, a figure which the actual cost of the work proved conservative.

In these states where the law requires that the contractors' estimate or bid shall fall below or within a certain per cent of the engineer's estimate, it is doubly important that the engineer's estimate be accurate and fair, otherwise lettings will be delayed or the contractor influenced to bid lower than his best judgment dictates.

Should the day ever come, when the cost plus contract is inflicted upon highway engineers, the trials of the estimator will be still further increased.

How to Prepare an Estimate on Highway Work.—Summing up these observations, to prepare an estimate of highway work:

1. Make an accurate quantity survey of the items of work entering into the contract.
2. Carefully estimate the unit prices of each item, using (a) your own personal cost data, (b) published prices of recent bids on similar work, (c) a preliminary estimate from a reliable contractor, (d) or, perhaps better, a combination of the three, checking one against the other. Tabulate these quantities and prices preferable on the regular progress estimate sheet and so lesson the chance of omitting any of the

items, and above all do not hazard a mere guess on any item but be ready to back each one with intelligent figures, based on local conditions.

Besides the engineers' preliminary estimate, in cronological order, comes the contractor's estimate or bid, the progress estimate, and last but not least the final estimate.

Contractors have long made sport of engineer's estimates, but since the bids submitted by contractors sometimes vary up to 100 per cent or more, while others frankly admit they are losing money, there is little cause for caustic comment by either the party of the first or of the second part. We have but little advice to offer the contractor; as a rule he understands his business, and understands how to figure his work. It is the exceptional one, who, by under-estimating, drives the prices below a living figure, and who is the despair of all conservative contractors and frequently of the engineers as well before the contract is finished. It is the reckless bidder who makes of contracting the gamble that it too frequently is. We more than surmize that the average contractor does not always systematically prepare his estimate, nor does he keep sufficiently detailed cost data to enable him to do so. For too often contractors bid against each other, instead of against the job and bids are submitted with the sole idea of landing the job, even though it be at considerable risk.

Contractors Should Prepare Bids in Accordance with Specifications.—Our first advice to the contractor is to read the specifications, and, secondly, to prepare his bid in accordance with those specifications. It will be immediately suggested that if this advice is followed, the other fellow would always get the contract. To which it may be replied that "one never loses money on the contract which the other fellow gets."

This advice may seem superfluous, yet some contractors boast that they never read the specifications and others beg with tears in their voices if not in their eyes to be released from some "unreasonable" clause which they didn't see and didn't bid on. Before signing a contract, a business man is usually very careful to scrutinize the various conditions therein contained. The specifications are a very important part of the contract and should be so considered. Several systematic readings of the entire specifications are good insurance against losses.

The contractor who prepares his bid with the idea of not carrying on the work in accordance with the specifications and later finds his mistake has little claim upon our sympathies. The engineer, however, has a duty here as well, to so revise his specifications that time-worn and long neglected clauses shall be eliminated and only such provisions as he actually intends to enforce are retained.

Progress Estimates.—Soon after work has begun, the progress estimate makes it appearance. This is an estimate of work done and materials delivered. It, too, should be carefully and systematically prepared. Usually the time allotted for its preparation is limited, some items cannot be accurately measured but by estimating these in several ways and checking them against each other, the chance of a considerable error is slight. The progress estimate should be made promptly on the date set, as the delay of even a few days may sometimes be embarrassing to a contractor, making it impossible for him to meet payments as he has promised, especially in the early stages of a contract. The contractor being a business man expects and appreciates business methods.

Formerly a monthly estimate was the almost universal practice, but with the advent of high prices and expensive pavements, it is not unusual to make estimates at more frequent intervals, thus relieving the contractor of carrying large material accounts over to another month. This is a practice which has much to recommend it and will undoubtedly be extended, and payments will be made more often than formerly.

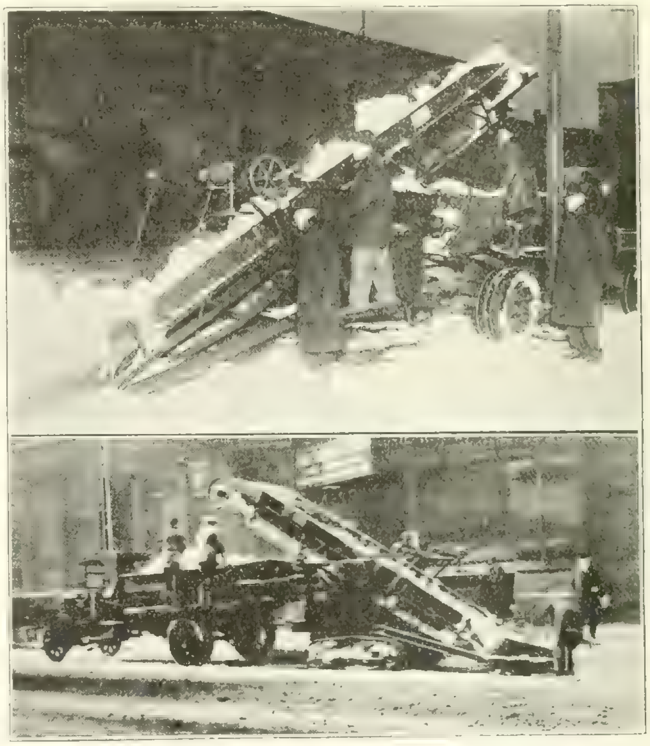
In preparing progress estimates, a little extra time and effort to measure and calculate accurately those items of work which are completed from time to time, will greatly lessen the work required on the final estimate and expedite a speedy settlement with the contractor. If the progress estimates have been carefully prepared and final measurements and notes taken as the different items of the work are completed, the preparation of the final estimate will be comparatively easy and there should be no delay in rendering the final estimate for payment.

Engineers should realize that the final payment is of great importance to the contractor, for not only is his 10 or 15 per cent of retained money held back but usually his last monthly estimate as well, and it should not be necessary for the contractor to wear a path to the Highway Department to get his final settlement as is sometimes done. As soon as the work is completed it should be accepted, if possible, and the final estimate rendered at the earliest practicable time.

A little stricter adherence to business methods and business promptness on the part of the engineers, in these matters, would result in lessened friction and misunderstanding between engineers and contractors and an increased co-operation with and respect for the engineer by the contractor. The state would share with the contractor the benefits of this increased co-operation and with the resulting efficiency.

New Snow Loading Machine

Many improvements in snow removal methods and equipment have been made during the past year. One of the latest developments is a snow loading machine, which received its initial test at Chicago last December following the first heavy snowfall of winter. The machine is of the belt conveyor type. It is mounted on crawlers to gain the best traction. It is powered by a Buda four-cylinder truck-type gasoline engine. A two-armed apron scoops up and turns the snow onto a wide cleated belt which carries it up to discharge into waiting motor trucks. This apron plow is adjustable. It is possible to scrape the surface clean or leave enough space to pass over any obstruction. Adjustment is made by the operator from his platform on the loader. Skirt boards 12 in. deep keep the largest lumps on the belt and give it an effective carrying width of 36 in. The belt is positive drive, being fitted with roller chain on each edge.


Loading Machine on Snow Removal Work at Chicago.

In its first trial Mr. W. J. Galligan, Assistant Superintendent of Streets of Chicago, placed the loader in operation at 7 a. m., Dec. 26, and with the exception of stopping for mealtime and one minor repair, it operated continuously until 3 p. m., Dec. 27, a continuous run of 32 hours. The loader continued in intermittent operation until Wednesday, Dec. 29, when the removal of the snow in the loop district had been completed. In this work the loader loaded snow at the rate of better than 3 cu. yd. per minute, although no provision had been made in the plowing and piling of snow for this machine. Trucks carrying 8 cu. yd. were "spotted" and loaded out in less than 5 minutes. During the period of operation, temperatures ranged from 32° above zero to 5° below zero, but no change was noted in the efficiency of the loader. During this same period, the snow ranged from slush to almost frozen, the loader apparently handling the different types of snow with equal success. It also was operated with equal success on bitulithic, wood block, granite block and cobblestone pavements.

The loader required the services of four men: one engineer to manipulate the loader, one helper for the engineer, who manipulated the plow, and two laborers whose time was used mostly at the plow end.

It is estimated that this loader effected a saving in labor of over $450 per 8-hour shift as compared with hand shoveling from piles into trucks. It also is expected that an equal saving can be effected in the hand work necessary to pile the snow along the gutter lines after plowing. Mr. Galligan estimates the cost of operating the loader at less than $30 per 8-hour shift, exclusive of interest and depreciation. The 25-H.P. Buda gas engine required less than 1 gal. of gasoline per hour and about 1 qt. of oil per 8-hour shift.

The snow loader is manufactured by the Barber-Greene Co., Aurora, Ill. It had its first tryouts in coal and ashes. Chicago expects to use its machine for handling ashes and gravel during the summer.

Problems of General Maintenance on All Types of Road Pavements*

By GEORGE H. BILES.
Assistant Commissioner, Pennsylvania State Highway Department.

Maintenance is a science in itself and affords the engineer a fertile field for research. The problems of maintenance are many and varied and the subject such an exhaustive one that we will be compelled, for the most part, to generalize, in order to touch certain important points in such a manner that a fair conception of it can be grasped.

Management.—The most important problem in connection with this whole subject in my judgment is management, but this is a study in itself. Suffice it to say that the functions of management, in addition to the responsibility for a business system, will include the thorough instruction of those in charge of the work in standard methods and processes to insure uniformity in results, which processes contemplate the locating and selection of satisfactory materials and supplies, the shipping and delivery thereof, the securing and distribution of equipment with its operation and maintenance, and the employment and payment of labor.

Methods of Operation.—When it comes down to the physical operation, there are two general systems of conducting this work, one by the caretaker or patrol plan, which in part is patterned after the French method, and the other by the patrol crew or gang. The former comes closer to the ideal, and, if properly controlled, gives very satisfactory results. This plan segregates the road mileage in sections ranging in length from 3 to 5 miles, depending on the type of the road, character and extent of traffic, with a patrolman amply supplied with tools, materials, etc., to keep up the small repairs and look after emergency work. He also can be used as a nucleus to form a larger force in the event that emergency demands. Operations of more magnitude, such as reconstruction, resurfacing and bituminous surface treatment, require special organization.

The arrangement just described must not be confused with the methods used in municipalities where pavements are constructed the full width of the street, with high curbs, and forces are provided to sweep and keep the surface clean from time to time and repairs are made either from a central plant of the municipality or by contractors. For the purpose of this paper we are using the ordinary interurban highway which is mostly constructed without the high curbs except through villages.

With the solid surfaces on such roadways and the undulating topography of the open country, the road is practically self-cleansing. The patrol gang is an organized force, generally of picked men, supplied with the necessary equipment and materials to take care of certain districts. From an economic standpoint, this is perhaps the cheaper way to do the work and can be justified under favorable conditions, but the best results are obtained from maintenance work when it can be carried on simultaneously. However, there are occasions when, due to the shortage of labor and the isolation of the work, this plan must be adopted.

Bridge Inspection and Maintenance.—There is no more vital problem in the maintenance of any highway than the safety of its bridges and culverts. Regular inspections should be made of all structures at least once each year, and oftener when any doubt exists as to their stability. Tests should be made after every period of heavy rain or high water to discover scour or undermining of the abutments or wing walls. It should be remembered that the deeper the water in the stream the more rapid and the greater the liability to scour. Steel structures should be examined as to the need of paint, also to ascertain if they are marked by corrosion. Stone and concrete bridges should be examined for cracks and signs of undermining. It is essential in all work in connection with the inspection, maintenance and repair of bridges and culverts that skilled labor be employed.

Snow Removal.—In addition to the surface maintenance, the universal demands of traffic call for the utilization of the highway the year round, and the removal of snow from the surfaces of the important highways has become an established practice. With mechanical devices and motor equipment with snow plow attachments this work can be carried on efficiently and expeditiously. Through the mountainous regions the great drifts are the source of most trouble. However, many of these are gradually being overcome to a considerable extent by the construction of snow fence.

Drainage.—Maintenance means to keep in a particular state or condition and this is our problem with the surface of the highways which must be kept true to grade and cross section in order that they may be preserved rigid and impervious. An irregular, uneven or wavy surface in any type of pavement is quick to show the effects of wear or disintegration. Our greatest difficulty is not a result of the abrasive action of traffic on the modern types of highways but is more often due to faulty foundation or drainage. I would say this is one of the most common forms of failures in all types of pavements. Water is one of the most destructive elements on our highways and defects will develop from time to time which are next to impossible to anticipate, and deterioration is hastened or controlled in proportion to the efforts employed to stay the destruction.

The maintenance engineer is often called upon to redesign drainage systems and supply new ones when they have been overlooked in the original construction. In addition to the elementary principles of this important study, such as drainage areas, soil conditions, waterway openings, velocity, coefficients, falls, etc., there are a few practical suggestions that may help. It is a good plan to check the results of formula with the physical when possible.

As an example, if a small culvert or drain is necessary, gather information as to conditions in wet seasons by locating high water marks, or, better still, if the course is crossed by other structures nearby, experience with them is a much bette guide than any formula. Side ditches and cross drains should be kept open and free of obstruction at all times. These ditches should be maintained of sufficient width and depth to properly dispose of the drainage and should be uniform as to grade and alignment.

In ordinary soil, side ditches should have a grade of not less than 1 ft. in 125 ft. The elevation of the bottom of the ditch should be lower than the top of the subgrade of the roadway at the shoulder. A wide ditch is recommended in preference to the narrow deep one which increases the velocity of the water and in some soils will scour and undermine the paving.

Water should be taken off the road at intervals by cutting ditches into the fields where possible, especially on steep grades, and where it is not possible to do this, the ditches should be paved with cobble or rubble. The shoulders of the roadway must be kept cut down to an even cross grade in order that the water from the road surface may be discharged in the side ditches. The trimming of shoulders can be done with a road machine or grader more economically and satisfactorily than by hand. It is necessary to do this at least once, and on some highways twice each season, depending upon the soil and traffic conditions.

Guard Railing.—With the increase in traffic on the highways, every precaution must be taken to insure its safety, and along the steep embankments, approaches to bridges, railroad crossings and sharp turns, substantial guard rails should be maintained. A safe and economical design has been found in the double line of ¾-in. cable wire run through posts 6 in. in diameter, set 8 ft. apart, the top line of wire

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*[illegible] presented [illegible]

6 in. from the top of the post, and the second line 1 below. The posts are 7 ft. long, 3 ft. 6 in. of which is above the surface of the ground. The wires are anchored at ends of sections and the fence reinforced at designated places, such as P. C.'s and P. T.'s of curves and certain points of grade changes.

Direction and Warning Signs.—The user of the road today no longer travels only from his home to his warehouse or to the railroad station or to his neighbor's home or to the county seat, but from county to county and from state line to state line, and signs of suitable design and construction must be erected to give full information as to direction and distances to important towns and intermediate points. The cast iron sign plate with heavy standard seems to be the most practical and as near fool-proof as possible. Studies have been carried on for a considerable length of time as to colors, with a view of obtaining the longest life and the best contrast by day and night. A yellow background with black letters for this purpose has proven most satisfactory.

The approaches to dangerous curves and railroad crossings should be marked with signs of similar construction with white background and black letters. The bottom of the plates should not be higher than 6 ft. above the elevation of the ground at the base of post.

Marking Detours.—The maintenance or detour signs marking an alternate route when repairs necessitate the closing of the main highway are a troublesome problem. Aside from the proper placing and marking of such signs, any sign of this sort seems to be the target for the small boy with his air rifle, the rowdy with any missile he can throw, the unthinking and irresponsible person who wants to pattern his gun or show his skill with a high power rifle. All forms of mischievousness are practiced on these signs, much to the annoyance and inconvenience of the persons using the highways, not to mention the chagrin of the road officials. It is suggested that light metal signs with white background and black letters be selected and stamped in such a way that, in addition to the standard marking, information can be stencilled upon them both for local and through traffic.

How to Repair a Bituminous Macadam Road.—We have dealt with the general problems of maintenance work up to this time, so let us take a concrete case and work it out. With the knowledge the engineer has of the particular design in each case, a study of the causes for deterioration or failures can be carried on with a view of taking remedial measures to correct them. Here is where we are called upon to diagnose the case and prescribe the treatment, but the analogy to medical procedure ends at this point, for instead of "burying our mistaks" according to the popular conception, they live to taunt us.

In private work no corporation would tolerate waste or incompetence and in public work the voice of the people is a formidable weapon and hence the greatest care must be exercised in making our determinations and selecting the proper methods and materials, for one of the greatest forms of economic waste today lies in the maintenance of the public roads of this country, and this is due principally to the lack of knowledge.

The bituminous macadam penetration road, in its various stages of disrepair or disintegration furnishes us a good subject for illustration. The most common deficiency found in this type of pavement is in the non-uniformity of the surface. Let us now proceed.

We have first, a section of road where the surface is composed of spots of excess bituminous material and bare or lean areas where the binder is lacking in quantity, which condition results in a short time in a ravelling or breaking up of the road surface. This condition is usually caused by improper distribution or by incorporating the bituminous material when the stone is not thoroughly dry.

Second.—A rough surface is presented where the stone is loosened or ravelled, the binder showing rapid deterioration, generally causing a series of pot holes. This may be occasioned by improper or overheated bituminous material unsatisfactory aggregate or faulty sub-drainage.

Third.—At times we have apparently a lifeless surface insofar as the bitumen is concerned, but upon further examination it is found to contain bituminous binder with considerable life a slight depth below the surface. This condition is due in many cases to an insufficiency of bituminous material

Fourth.—A pavement may present a wavy and uneven appearance and this is usually due to an excess of bituminous material or is caused by the bituminous material being too soft to withstand the action of traffic.

Fifth.—There are surfaces which consist of ridges of material which are the result of irregular or improper pouring—in most cases, careless hand pouring. A surface of this kind suffers quickly from the impact of traffic and the attack of the elements, and early disintegration is the result.

Sixth.—We have a fairly well shaped, uniform surface becoming porous. This condition is true of all bituminous highways in time, as it represents the beginning of the deterioration of the bituminous material.

It will be seen that before repairs are taken up on bituminous macadam roads, careful study and examination are necessary in order to select the most effective method. Taking the several conditions in order as hereinbefore mentioned, the first case, if taken in time, can be repaired by sealing the dry or lean spots in the surface with a light, heated application of bituminous cement of the binder grade, or the cold bituminous surface treatment materials in quantities ranging from 0.1 gal. to 0.3 gal. to the square yard of surface, covered with chips or pea gravel, using between 15 and 20 lb. to the square yard. Unless the surface is worn badly, repairs of this character will even up the surface to a true cross-section, giving added life to the pavement.

The second condition, if of any great extent, calls for heroic treatment and a complete scarifying and harrowing of the surface becomes necessary. All disintegrated material must be removed and sufficient new stone added to give the required depth before the surface can be repenetrated and sealed as in the original construction. If, however, the affected portions are only occasional and do not represent the greater area, they may be cut out, cleaned thoroughly and filled with new stone, making due allowance for compression, then penetrated, etc., in the manner hereinbefore mentioned. If drainage conditions are responsible for the failure, they must be corrected before any surface repairs are taken up.

The condition described in the third example may be treated in two ways. The most economical so far as first cost is concerned would be to give the pavement a treatment, in sufficient quantity to fill the surface voids, with a material that will penetrate and enliven the old material, followed by a covering of good, hard stone chips, using about 20 lb. to the square yard. The alternative would be to scarify and harrow the whole surface, supplying additional new stone in quantities as the rolling would indicate to be required to give the proper cross-section, and penetrating the surface with a bituminous binder, sealing again as in the original construction. In the latter method, the surface must first be thoroughly cleaned, and in scarifying and harrowing, the remaining bituminous material in the road must be distributed as evenly as possible. If the material found in the pavement, however, does not possess life, this method is a hazard.

Fourth.—In the wavy, corrugated surface, where there is found to be an excess of bituminous material, it is generally more economical and satisfactory to scarify and reshape the surface, adding new stone in order to take up the excess bitumen, and again sealing the surface. This same method should be followed where waves have been caused by the bituminous material being too soft, only, perhaps, more stone would be required in the reconstruction and it would be essential to incorporate a harder bituminous binder than was used in the original construction.

Occasional waves in the surface may be taken out in the due course of ordinary repairs, if the conditions are very pronounced, by cutting off or planing the high places and resealing, or by cutting out the depressions and replacing with new material.

Fifth.—A surface full of ridges, due to improper pouring, if not too pronounced may be evened up by painting between the ridges with bituminous cement and covering with stone chips or gravel. This method may be continued from time to time until the surface is entirely evened up. This condition may also be corrected by scarifying the surface with the object of obtaining a more uniform distribution of the old bituminous material, and, after rolling to the proper shape, by applying a surface treatment of a cold bituminous material that will enliven the existing material and seal the surface. This treatment is covered with stone chips in the manner prescribed for regular bituminous surface treatment work.

In the last case, we have a properly constructed bituminous penetration pavement but the bituminous material is starting to deteriorate. This can be enlivened or revived by cleaning the surface and applying a seal coat of material in quantities depending upon the degree of disintegration. Caution should be exercised to avoid applying an excess amount, which results in a slippery condition and is very objectionable to horse-drawn traffic. Generally 0.1 to 1/6 gal. is used and brushed into the surface with hand brooms. The surface is then covered with chips or gravel approximating 20 lb. to the square yard. In the use of certain slow drying cold bituminous materials it will be observed that the new material softens up the old bitumen somewhat, giving the appearance at first of an excess application, and, having a hard surface underneath, the road becomes quite slippery, but this condition obtains for only a short period of time.

To insure the best results one-half of the road should be treated at a time in order that the traffic may use the other portion while the bituminous material is setting up. This method has become quite effective and results in increased life to the pavement.

In the repairs of breaks, depressions and local defects, which may occur under any one of the general conditions previously outlined, it is more satisfactory to use hot bituminous binders, and if replacements are necessary, they can be made after the fashion of the original construction. This work can be done very efficiently in this manner with little equipment and the average class of labor. There are a number of instances where cold bituminous compounds can and are being used successfully in certain seasons of the year on pavements of this kind, but in cold weather there is usually difficulty with some of this material, owing to its composition. As an example, the emulsified products break down or separate and their adhesiveness is destroyed at low temperatures. Materials that are cut back with natural solvents can be used later and give very good results. The mixtures can be prepared at some point not exposed to the weather but convenient to the work, hauled to the site of the repairs, and deposited. This is an effective method in case of emergency.

Why Highway Contractors Lose Money*

By MAX CUNNINGHAM,

Formerly Chief Engineer, Oklahoma State Highway Commission.

My experience has taught me to believe that one of the first things any highway contractor must do is to forget that he ever did any work other than highway jobs. This comes from the fact that many highway contractors' organizations are made up of men with considerable experience in railway work who will be big losers until they can forget this fact.

The engineer locating a railway is bound by definite limits of grade and curvature, controlled in turn by actual or estimated tonnage requirement, and affected only generally by local topography.

Highway and Railroad Construction Differ.—Your highway engineer does not have to figure on draw-bar pull, train tonnage, wear of track, or any of these things, and while he has certain arbitrary ruling grades and curves to govern him, these are usually so liberal that a general statement may be made that "a highway profile means nothing to a contractor." This is rather a broad statement, but a little consideration will show you how true it may be. No railway will break a tangent or exceed its "virtual" profile to dodge a rock cut, but it is done every day in the field of highway work. Compensation for distance is common railway practice, rise and fall of grade has a definite tonnage value, but the scenic appeal of a highway frequently causes things to be done that are absolutely foreign to the railway engineer and his contractors.

Consideration of this statement will cause you to realize that "quantities" in highway grading come almost entirely from the width of the crowns, and on most jobs the only real grading is across stream bottoms where material is mostly undesirable. For these reasons it is necessary to build up an entirely different line of "subs" and you should be particularly careful to figure in your bids, and, in your dealings with sub-contractors, enough for finishing—and then double it.

The job that would be entirely acceptable to a competent resident engineer will probably be unsatisfactory to the local critic, and you must figure on him.

I have also found that many bidders on general contracts fail to sufficiently estimate the cost of "extensions" to existing structures. Bids made on unit basis for considerable quantities of masonry are frequently figured on an "appearance" basis, and the builder finds he has "end walls" and "extensions" where the total price received for the units built will not pay for the expense of getting the men to the job. This may be balanced by the price received for the volume of work, but too frequently must be carried as a loss against a part of the work that cannot carry a loss.

The Equipment Question.—The question of adequate plant is one that is important enough to call for a paper in itself, but my advice would be for the highway contractor to specialize. You do best that you like best, and your whole plant should be built around this idea.

Too many men have lost by using mules they had rather than invest in trucks that would have saved and earned money. The reverse has frequently occurred. In these days of scarce and inefficient labor, and eager and inefficient bidders, no one should undertake work unless he is satisfied that he is equipped or able to equip to handle it economically. Plant study, with the aid of a real expert, would pay anyone, and where he has secured proper plant, and efficient and satisfactory organization, he should bid on only such work as he is ready to build right.

Don't Forget You Work for the Public.—The things mentioned are all of great importance, but the highway contractor should never lose sight of the fact that he is dealing with the public, and not with a private or public service corporation. Particularly he should study the specifications, for the balance of his contract can only be interpreted with them as a key.

He should study the men in charge of the work, and then discount that study. No matter how good the man may be, he is liable to lose out at any time, and it is almost a certainty that he cannot dictate his employes, and in many cases his appropriations are so small that he cannot keep good men if he has them.

These factors have a great bearing on the financial success of the contractor, and must be considered carefully in making bids.

Most contractors realize now that they should get all of a contract, so as to be in a position to co-ordinate the various steps, but do not forget that the policy of most highway departments is to increase the size of jobs, so as to have fewer men to deal with, and most contractors encourage them, hoping to be fortunate enough to land one of these real jobs. This is the most dangerous of policies.

Pick One-Season Jobs to Build Right.—My earnest advice to every highway contractor would be to pick the job you want, organize to build it right, and quickly, and never to take on a job that will take more than one season to build.

Your chief engineer and all his help are employed by a great public, and are subject to all kinds of criticism (mostly unfriendly), and you are paid by the same public. A private corporation is willing for you to make money at their price because you will be a better man for the next job, but it is most unfortunate that the unreasoning public is inclined to think and claim "graft" if you work for a profit, and the man who has his money in plant and job has too many chances to suffer if his work goes over two or more seasons.

Traffic Guide Lines on Concrete Roads.—In the interest of safety the Road Commissioners of Wayne county, Michigan, are painting white dividing lines on the county concrete roads. The commissioners find that this procedure has a decided tendency to keep traffic on its own side of the road.

North Carolina Engineers' License Bill Bassed.—The North Carolina legislature has passed the engineers' license law prepared by and introduced at the instance of the North Carolina Assembly of the American Association of Engineers. The bill now goes to the governor for signature.

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*[illegible] Jan. 25 at the Second National Conference of Associated General Contractors.

Special Winch for Road Tractor

A winch attachment for road and contracting work requiring a winding drum is the latest attachment available on the Avery Tractor, manufactured by Avery Co., Peoria, Ill. It is also available for pulling tubing from oil wells or work of a similar nature. The winch is located at the front of the machine and all the control mechanism is operated by a man standing on the ground in front of the machine, where he can see all of the work going on and has absolute control of the mechanism at all times. The winch is so constructed that it takes its power direct off the motor and is, therefore, entirely independent of the traction gears. In fact, there is not a gear of any kind in mesh except on the winch itself when it is being operated. The power of the motor is transmitted to the winch by means of two sprocket wheels and a Diamond roller chain. The small sprocket is attached to the flywheel of the motor and the larger one to the countershaft of the winch. The ratio between the two sprockets is 3 to 1.

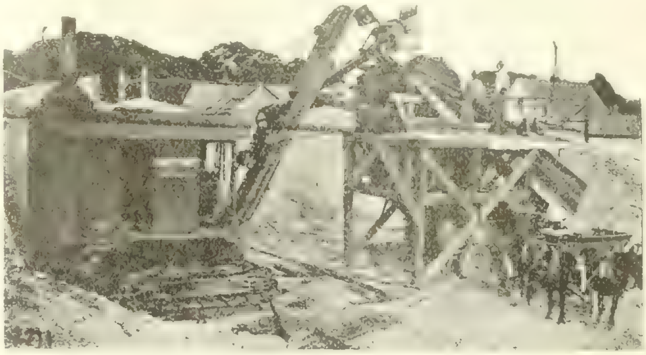
Only one clutch is used on the winch of the multiple disc dry plate type and located on the countershaft of the drum. A service brake 17 in. in diameter with a 3-in. face lined with Raybestos is located on the spool. It is operated by a lever conveniently located in front with the clutch lever so that the operator can handle both clutch and brake lever with ease. The winch attachment is built strong of good materials throughout. The countershaft and drum shaft are cold rolled steel, and each is 2½ in. in diameter. The pinion on the countershaft and the large gear on the drum are cast steel and semi-steel, respectively. The diameter of the winding drum spool is 7 in., while the flange on either side is 19 in. in diameter. The width of the spool between the two flanges is 16 in. The winch will handle approximately 5,000 lb. at 150 ft. per minute and in reverse operated at a speed of 225 ft. per minute. The spool will carry about 1,300 ft. of ½-in. cable, 850 ft. of 5-in. cable; 570 ft. of ¾-in. cable, or 410 ft. of ⅞-in. cable.

12/25 Avery Equipped with the Winch Pulling Oil Well Tubes at Bartlesville, Okla.

Chinese to Hold Roads Convention.—Plans have been started by Dr. C. T. Wang, head of the good roads committee of the recently organized Pan-Pacific union, to hold a good roads convention in Shanghai in the spring of 1921. The immediate purposes of the convention will be to discuss the projects of building roads from Shanghai to Hangchow and from Shanghai to Nanking.

Combined Movable Gravel Bin and Grizzly Loaded by Steam Shovel

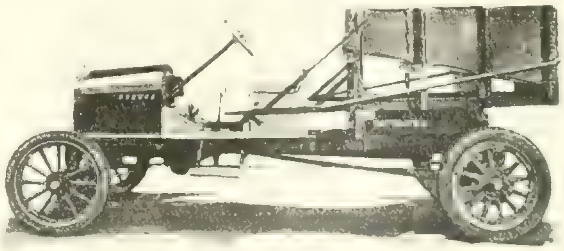
The arrangement shown in the illustration, reproduced from the Excavating Engineer, is used by W. C. McLeod, a contractor of Livingston, Mont., for securing gravel for a paving job. The gravel is separated from the oversize and fed directly into trucks underneath the bin, whereas the oversize passes over a side spill into wagons as may be seen from the ilustration. The bin is mounted on skids, to which are attached chains, the other ends of which are fastened to the body of the shovel. This arrangement makes it possible for the grizzly to be moved with the shovel at a constant distance, so as to enable the shovel to load into the grizzly without maneuvering. This shovel is equipped with a standard length boom and dipper handle, which according to the manufacturer's specifications allows a clear dumping height of 13 ft. 8 in. Mr. McLeod, however, is obtaining a lift of 17 ft. 6 in., measured vertically from the top of the grizzly to the blocks on which the caterpillars rest. A further 6-in. lift is made possible by the use of 6-in. blocking underneath the caterpillars. The shovel is stated to be getting 200 cu. yd. of oversize, which is hauled away in wagons, making a total of of 300 cu. yd. per day; 2,000 lb. of coal is being consumed per day.



Gravel Bin and Grizzly.

New Dump Body for Small Trucks

A new patent dump body built to fit any Ford 1-ton chassis has been brought out recently by the Haddon Manufacturing Co., Omaha, Neb. It is stated that the body can be attached to the chassis in 20 minutes. The body is operated by the driver without moving from his seat. The dumping lever also automatically controls the end gate, opening it as the body rises for dumping and closing it as the body returns to normal position. The body is 30 in. wide and 60 in. long, and has a ¾ yd. capacity. It is built with a floor sloping to the back, with a depth of 12 in. in front and 24 in. at the rear. The body can also be furnished for any capacity from 18 cu. ft. to 30 cu. ft.

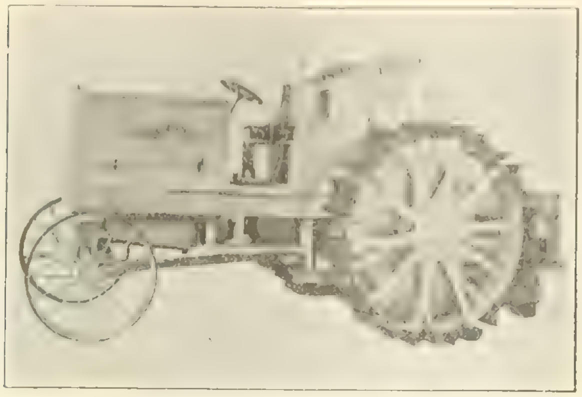


Dump Body on Ford Chassis.

Machine Handling of Concrete Road Materials.—In our issue of Feb. 2 we published an article describing the handling of aggregate for concrete road construction by self-feeding bucket loaders. Through an oversight we neglected to state that in the table on page 120 giving costs of material handling by this method, the averages in the column headed "Results—average feet per day," were calculated on the basis of an 18-ft. wide road.

A Tractor Shovel

A new dirt moving machine consisting of a combination of tractor and shovel bucket has been placed on the market by the Pioneer Tractor Mfg. Co., Winona, Minn. The machine is of simple construction, containing a shovel bucket with power for its operation. It is single, compact unit, with proper speeds to make it particularly mobile. Quick handling is facilitated by the short wheel base and turning radius. The tractor has two reverse speeds so that in grading the machine can be backed directly over the same path as traveled with the loads, thus doing away with the necessity of circling from point of dump to point of loading. The shovel bucket has a length of 52 in., a width of 48 in., and a height of 25 in. Its capacity is 1½ cu. yd. It is constructed of ¼ in hot rolled steel plate and has reinforced bottom and sides. The bucket is raised and lowered from the driver's seat by a clutch lever, and is positively driven through cut steel gears. The load may be dumped in one position or spread, as desired. The motor is of the heavy duty tractor type of 40 B. h.p. There are two speeds forward, and reverse on both speeds. The low or filling speed is 1¼ miles per hour and the high or travel speed 3½ miles per hour. The machine is intended for use in highway construction, such as grading, making cuts and fills, finishing road surfaces. It can also be used for other earth moving operations.



Pioneer Tractor Shovel.

Tractor With Rear Wheel Removed to Show Position of Bucket in Dumping.

Herbert Hoover in the Cabinet

It may be said without exaggeration that the American people, irrespective of political or other affiliation, will rejoice over the definite announcement that Herbert C. Hoover has accepted the position of secretary of commerce in the Harding cabinet.

Among politicians Mr. Hoover has a few—very few—bitter enemies and detractors, but the overwhelming majority of the people of this country and all the foreign statesmen and relief workers who have come in contact with him respect and admire his ability, his public spiritedness, his genius for organization and his faculty of appealing successfully to the better nature of humanity.

The portfolio of commerce is not at present important. Mr. Hoover knows that and would not have accepted had not Mr. Harding assured him cordial support of certain plans for the reorganization and development of the department. It can and ought to be one of the most constructive and useful departments in any modern governmental structure. Mr. Hoover is the man for the job, since he is not only a distinguished engineer but has exceptional knowledge of world affairs and trade problems.

With Charles E. Hughes and Herbert C. Hoover in the cabinet these republicans who have been disturbed by rumors and constrained to sound warnings of the dangers of mediocre and purely political advisers must feel measurably reassured. Several other selections are still tentative. But Hughes and Hoover would lend prestige and distinction to any cabinet.—Editorial in Chicago Daily News.

National Engineering Conference on Public Information. The outstanding feature of the first national engineering conference on public information, held by the American Association of Engineers in Chicago on Feb. 25, was the practical discussion of actual working details of publicity, policies and methods. The conference was not a meeting in the sense that a considerable crowd gathered to hear addresses on various subjects. On the other hand, those present gathered around a huge T-shaped table and more than 60 per cent of those present actually joined in the discussions. Engineering public information and methods were discussed so fully as to bring out methods which can be used by a national organization, a local society, an individual or by a combination of the three. The report of the conference will be made the basis of a pamphlet on engineering publicity which will be printed and distributed by the American Association of Engineers for the benefit of other societies and the 245 local chapters and clubs of the association. The crystallization of the thought of the conference was somewhat as follows: The engineering profession needs broad constructive publicity as an indispensible element of public service. A policy must be determined which will insure a constructive and progressive program of publicity. Sources of information must be located and the flow of information from them directed to a national co-ordinating office, from which the informational service must flow to national sources of publicity and local sources for reactivation and local application.

Personals

John Stamm, for 15 years road superintendent of Pueblo County, Colorado, has been engaged by Yuma County to serve in a similar capacity.

William B. Reed, of Weedsport, N. Y., district supervisor in the New York State Highway Department since 1910, has been appointed third deputy commissioner of the State Highway Department.

M. L. Dean, dyking engineer of Walla Walla County, Washington, has been named consulting engineer for roads in this county, and will have charge of all road maintenance work in connection with his other duties.

W. E. Bond, a civil engineer with the Henry Ford Automobile Co., has been appointed assistant forester in charge of silvical investigation, including all matters pertaining to silviculture in the State forestry department of Vermont.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently.

Street Sweepers.—Austin-Western Road Machinery Co., Chicago, Ill. 4 page circular illustrating and describing the Austin motor sweeper.

Resurfacing Pavements.—Barber Asphalt Paving Co., Philadelphia, Pa. 16 page booklet describing methods of resurfacing various types of roads and streets with asphalt.

Gasoline Locomotives.—Fate-Root-Heath Co., Plymouth, O. 24 page catalog devoted to descriptions and illustrations of the Plymouth locomotives in road construction.

Steel Forms.—Lakewood Engineering Co., Cleveland, O. 16-page booklet describing the Lakewood-Hotchkiss line of steel forms for road, sidewalk, curb, gutter, culvert, foundation and wall construction.

Motor Trucks.—The White Co., Cleveland, O. 28 page booklet entitled "Contract Hauling with White Trucks." Contains experience stories of several White fleet owners, engaged in various kinds of contract hauling.

Asphalt Macadam.—Asphalt Sales Department, The Texas Co., 17 Battery Pl., New York City. 12 page booklet describing procedure in constructing Texaco asphalt macadam. Cross sections and photographs showing steps in construction are included.

Stone and Lime Handling Machinery.—Link-Belt Co., Chicago. 80 page catalog divided into sections, the first devoted to stone handling and the second to lime handling. Contains illustrations and descriptions of typical installations of elevating and conveying machinery, together with discussion of some of the elements used in their construction.

Waterworks and Hydraulics Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The Remarkable Progress of America Under the Capitalistic System

Under the "capitalist system," which the socialists decry, America has steadily increased in per capita productivity and correspondingly in the average income of the workers measured not only in dollars but in commodities. Frank H. Sisson, vice president of the Guarantee Trust Co. of New York, recently published the following statistics showing the percentages of the world's total output of basic commodities annually produced in the United States:

	Per cent of total.
Wheat	[illegible]
Corn	[illegible]
Cotton	60
Cattle	27
Dairy products	[illegible]
Iron and steel	40
Copper	60
Gold	[illegible]
Silver	[illegible]
Coal	[illegible]
Oil	[illegible]
Automobiles	85

"In brief, we contribute one-quarter of the world's agricultural products, one-third of its manufactured goods, and more than one-third of its mineral products. . . We have one-third of all the gold coin and bullion in the world, which constitutes the basis for our credit structure. . . . Notwithstanding that the United States has only 6 per cent of the population of the world and only 7 per cent of the land, the bank deposits and resources of this country exceed the combined bank deposits and resources of the whole world."

It is an astonishing statement that one-seventeenth of the population of this globe produces one-third of the minerals and manufactured products, but it is doubtless approximately true. We do not believe, however, that America produces "one-quarter of the world's agricultural products," for it must be remembered that no record is kept of all the agricultural products in every country. The total output of vegetables, fruits and dairy products is not known for most countries, and is only approximately known for America.

During the 40 years between 1869 and 1909, the annual per capita production of commodities in America exactly doubled, and during the same period the annual income of the average worker also doubled, this income being measured in commodities purchasable with the annual wage. Prof. King and other economists estimate that 75 per cent of the total annual income in America goes to the workers and 25 per cent to the capitalists, many of whom are also workers. It follows, therefore, that the much maligned "capitalistic system" has at least not stood in the way of an amazing increase in the income of the average American worker.

Although communistic systems have been repeatedly tried, both on large and on small scales, in no instance has there resulted an increase in the real income of the average worker at all comparable to what has occurred under the capitalistic system here in America. The capitalistic system has defects, some of which are serious, but before it is rejected it should be proved by experiment that some other system is more effective. At present four large commonwealths are experimenting with socialistic forms of government, namely, Australia, Austria, Germany and Russia. A dozen years ago socialists were making glowing predictions about the Australian experiment; but they are saying very little about it now. Russia and Austria have been going rapidly from bad to worse under their socialistic governments; but socialists declare that this is largely due to the wrecking of their industrial organizations by the war. On the other hand, capitalistic Belgium has been steadily improving industrially since the war ended, and certainly no nation was so badly wrecked by the war.

In science no theory, however plausible, is accepted until it is found to accord in every case, with observation or experiment. If government is ever to become scientific, it must be founded upon the principle that no theory of government should be declared true until it has been thoroughly tested by experience. But socialistic writers insist that communism is founded upon true theory, in spite of the fact that every communistic experiment thus far made has shown results contrary to those predicted under the theory. The grand defect in the theory of communism appears to be in the assumption that human selfishness can be ignored as a factor in calculating the output of the average worker. The socialistic theory assumes the existence of an average worker who is highly altruistic and at the same time sufficiently imaginative to realize that if he lowers his individual efficiency he will suffer in the end. That the average worker is no such ideal person is evident to any one who will but use his eyes.

We trust that Germany or Austria will continue under socialistic government for 10 years. At the end of that time it should be evident even to the most enthusiastic socialist that socialism has far greater economic defects than capitalism.

An Erroneous Decision by the California Railroad Commission

The California Railroad Commission, in common with many other public service commissions, has leaned strongly toward the theory that the proper "rate making value" of a public service company plant is the actual cost of the plant. It would logically follow that the "intangible value" to be added to the "plant value" should be the actual cost of establishing or building up the business. This development cost or "going value" is commonly calculated by estimating the accumulated deficits below a fair return (usually taken at 8 per cent annually) on the cost of the plant. In a recent decision the California Railroad Commission rejects this deficit method, saying with regard to it:

> There would follow this absurd result: The greater the losses incurred in a utility business the greater its value, and the less profitable the business the larger the "just compensation" to the owner. The mere statement of such a theory proves its absurdity.

It is interesting to note that this very argument against the deficit method (or Wisconsin Commission method, as it is often called), was used many years ago by the Supreme Court of California. None the less the argument is fallacious. The fallacy is concealed in the double meaning of the word "value." The California Commission uses the expression "rate making value" as being synonymous with actual cost. Strictly speaking, however, plant cost and plant value are seldom the same. The true value of a plant is its capitalized prospective net earnings, which may or may not equal the cost of the plant. In rejecting development cost based on deficits, the California Commission sets up the criterion of true value; for it is clear that true value is not enhanced because of deficits, but the reverse. On the other hand, the Commission does not apply the criterion of true value in estimating the "rate making value" of the plant, but applies the criterion of actual cost. In other words, it uses one criterion (cost) for the "plant value," and another criterion (true value) for the development cost or "going value."

A cost may be unreasonably high, but the fact that it is too high logically leads merely to scaling it down to a reasonable amount. Hence if a given development cost is unreasonably high it should be scaled down, but not rejected in toto. The California Commission, however, does not state that the development cost in question was unreasonably high, but rejects it entirely by applying the criterion of true value, although such a criterion is never applicable to any cost whatsoever. Putting the matter in another way, if the actual reasonable cost of a public utility plant should be taken as part of the "rate making value," then the actual reasonable cost of building up the plant's business should be taken as the remaining part of the "rate making value."

Reply may be made that because this particular appraisal was to be used in estabilshing a purchase value (the city of Banning contemplating buying the electric light and power plant), actual costs, whether of plant or of attached business, should have no weight at all in establishing the purchase price; but it should be remembered that the California Commission clings very closely to actual costs in rate cases, and that so long as this is done, a public utility plant can not have a real or commercial value much different from the actual cost.

The California Commission is one of the most careful of all rate-making bodies, and it has established an enviable reputation for fairness. We believe, therefore, that it will ultimately reverse itself on the ruling under discussion, for it is based on the use of inconsistent criteria of "value."

Classification of Water Consumption in Various American Cities

The following table from the recent report on the water [illegible] Kansas City, Mo., by Fuller & McClintock, consulting engineers, affords an interesting comparison of the use of water in various cities:

	Domestic use.		Industrial and commercial use.		Municipal use.		Under-registration of meters.		Leakage and waste.		Total consumption.
	G. c. d.	Per cent.	G. c. d.	Per cent.	G. c. d.	Per cent.	G. c. d.	Per cent.	G. c. d.	Per cent.	G. c. d.
[illegible]	40.0	42.0	[illegible]	42.0	5.0	5.0	2.5	2.5	10.0	10.5	95.0
[illegible]	40.5	[illegible]	[illegible]	29.0	13.0	11.0	3.0	2.5	15.0	13.0	117.3
[illegible]	45.0	[illegible]	[illegible]	36.0	23.0	17.5	3.4	2.5	13.2	10.0	132.0
[illegible]	45.0	[illegible]	[illegible]	42.5	7.0	6.0	...		17.0	14.5	119.0
[illegible]	30.0	[illegible]	[illegible]	[illegible]	3.0	3.0	...	.	32.0	34.0	95.0
[illegible]	26.0	[illegible]	[illegible]	42.0	10.0	10.0	..	.	20.0	21.0	96.0
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	2.5		..	37.0	31.0	118.0
[illegible]	40.5	[illegible]	[illegible]	[illegible]	[illegible]	20.1	2.1	1.5	18.4	13.5	137.7
[illegible]	40.0	[illegible]	[illegible]	[illegible]	15.7	12.5	2.1	1.7	18.4	14.6	125.7

[1] [illegible] requirements 1916. [2] Under leakage and waste are included unmetered houses, street and sewer flushing. [3] Actual except [illegible] between domestic and industrial, which is in part estimated. [4] Estimated with sewer flush tanks shut off and street cleaning.

Detecting Water Waste with Dionic Tester.—The dionic water tester has given good results at Ottawa, Ont., in examining water samples suspected of being derived from leakages. The tester was used to determine the electrical conductivity, and in the case of the Ottawa supply, the low conductivity (about 20 units) made it easy to distinguish the supply from ground water, well water and sewage. Very few instances occurred in which the results were in any way ambiguous. In a communication in the November Journal of the American Waterworks Association, Dr. Joseph Race states that the apparatus can be assembled and the test completed within two minutes. He further adds that he would recommend this method for cities in which the conditions are similar to those prevailing in Ottawa because of its reliability and speed, the latter being quite an appreciable factor when excavations have to be kept open pending a report from the laboratory. The electrical conductivity test also affords a rapid means of detecting changes in the supply, for the conductance, or reciprocal of the conductivity, is proportional to the mineral content.

Engineering License Bills.—In Missouri, the Senate Bill to license architects, professional engineers, and land surveyors has passed the state senate and is now before the house. In New Jersey, the license bill is out of committee and ready for second reading. In North Carolina, the bill introduced in the legislature at the instance of the North Carolina Assembly of the American Association of Engineers has been passed by both the Senate and the House, and is before the Governor for signature.

Short Course for Waterworks Operators.—The Texas Water Works Association announces a third short course for water and filter plant operators to be given by the Texas State Board of Health in co-operation with the Baylor University at Waco, for the week beginning April 11. All Texas operators are invited to attend. Lectures and demonstrations on the operation of filter plants will be given. V. M. Ehlers, Austin, Tex., is Secretary of the association.

River and Harbor Bill Passed.—The U. S. Senate on Feb. 25 passed the Rivers and Harbor Bill carrying new appropriations of $15,000,000 and authority for expending $47,000,000 in unexpended balances.

Book Review

Water Purification Plants and Their Operat[illegible] [illegible] Stein, Mem. Am. Soc. C. E. New York, John Wiley & Sons. Cloth 6x9 in., ill., pp. 270. Second Edition.

The second edition of this volume has been made necessary because of the advance and changes which have occurred in the technique of water bacteriology since the book was first published in 1915 and reviewed in Engineering and Contracting, Jan. 19, 1916, page 71. A complete outline of the contents of the earlier edition was then presented and will not be repeated here. The principal changes occur in the chapters which deal with bacteriology and the interpretation of tests. Present day practice is incorporated in the instructions to operators, and new interpretation of bacteriological tests are included.

The treatment of the subject matter throughout, though somewhat arbitrary, is such that it may be well understood by the non-technical man, and yet be a ready reference for the experienced operator. The early edition was a pioneer in its field and the present revised edition still maintains its position among others.

Cost of Garbage Collection and Disposal at Trenton, N. J.

To the Editor: Your Feb. 9, 1921, issue contained an article (p. 42) entitled "Comparative Costs of Street Cleaning, Ash and Garbage Collection and Disposal," which gives the cost per ton for the collection and disposal of ashes, rubbish and garbage in Trenton at $6.27.

The actual cost, for the year 1920, is as follows:

15,430 tons of garbage and combustible refuse collected at a cost of $39,371.67 or a fraction over $2.55 per ton. This includes the hauling of 1,192 tons an average of three miles into the country to feed to pigs.

14,248 tons of garbage and combustible refuse incinerated at a cost of $11,248.20, or a fraction under 80 ct. per ton for disposal.

68,420 tons of ashes collected and dumped on low ground, average haul about 1½ miles at a cost of $56,432.74, or a fraction over 82 ct. per ton.

83,850 tons of garbage, combustible refuse and ashes were collected and disposed of at a cost of $107,052.61, or at a cost of a fraction over $1.27 per ton.

G. B. LABARRE,
Director Department of Public Safety.
Trenton, N. J.

Co-operative Bacterial Tests on Missouri River Water.—In May and June, 1920, a co-operative series of tests was made by various laboratories to show the change in bacterial content of the water of the Missouri River. Five sets of samples were taken at various points from Omaha to Kansas City, the time between samples being such as the water of the river would normally require to flow from point to point. The average results of the five sets are summarized as follows in a recent report of Fuller & McClintock, consulting engineers, on the water supply of Kansas City, Mo.:

Sampling point.	Distance in miles	Bacteria per cc.		B. coli in 0.01 cc.	
		20°	37°	Positive	Total tests
Omaha, Neb.	0	54,000	13,800	[illegible]	[illegible]
St. Joseph, Mo.	181	78,000	[illegible]	[illegible]	[illegible]
Atchison, Kans.	212	64,000	65,000	[illegible]	[illegible]
Leavenworth, Kans.	238	131,000	40,000	[illegible]	[illegible]
Quindaro	261	117,000	[illegible]	[illegible]	[illegible]
Hannibal Bridge	269	184,000	72,000	[illegible]	25

Per Capita Water Consumption in Several Large American Cities.—The following table is taken from a report on the water supply of Kansas City, Mo., submitted last December by Fuller & McClintock, consulting engineers:

City.	Year.	Estimated population.	[illegible]	Percentage of services metered.
New Orleans	1916	378,000	[illegible]	100
Atlanta	1916	200,000	[illegible]	100
Columbus	1919	232,000	[illegible]	97
Cleveland	1916	845,000	[illegible]	98
Milwaukee	1919	500,000	[illegible]	99
Toledo	1919	235,000	[illegible]	85
Cincinnati	1918	415,000	[illegible]	86
Los Angeles	1916	533,535	[illegible]	88
Washington	1916	364,088	[illegible]	[illegible]
St. Louis	1916	755,000	130	7
Newark, N. J.	1918	408,000	118	90
Kansas City	1920	334,192	138	72

Stifling Water-Power Development Through Inaction

With a keen perception of political values Congress is giving attention to certain phases of legislation of doubtful value. Over the veto of the president it has passed legislation providing for loans to farmers, and with a great show of interest in the public welfare it is considering emergency tariff legislation. At the same time a bill of tremendous import to industrial progress is allowed to rest peacefully in the hands of the select committee of the House of Representatives on water power. Political expediency evidently dictates this course, but the chemical industries, with others that need power for effective development, may well ask why class legislation is crowding out their legitimate needs.

We refer to the bill introduced by Representative Esch (H.R. 15126) providing slightly enlarged authority for the Federal Power Commission to employ appropriate personnel, either from outside the government or by transfer from other executive departments. At the present time there is pending bfore the power commission a mass of applications for power development which represents 13,000,000 hp. in potential energy supply. This is five times as much business as has been handled in over twenty years by all of the executive departments previously in charge of these affairs. And to care for it congress permits these departments to loan a few members of their staff to the power commission to do the work. At the present rate one hundred years will be required to care for the applications already pending, and more arrive every day.

Chemical industry, especially the metallurgical and electrochemical industries, need extensive power developments in all parts of the country so that one of their raw materials, electrical energy, will be available in adequate quantity at reasonable price. They do not ask that the Federal Government go out and spend money on this development. They can reasonably demand, and they do, that the Federal Government permit this commission to do business effectively and promptly, so that the horsepower now going to waste can be put into productive use for the benefit of all. The electrical industry, the prospective customers of that industry, and public officials all agree that the present legislation is adequate for development and safeguarding such investments. Why should we, therefore, stand marking time industrially simply because the federal agency which must handle these matters is tied hand and foot for want of a paltry few thousand dollars and is compelled to work only with borrowed help? We understand that the House rules prevent immediate consideration of this measure; but it seems likely that if the chairman of the Rules Committee were sufficiently impressed with the importance of action at this session of congress the necessary steps could be taken to insure it. We suggest this procedure to those concerned in early water-power development.—Editorial in Chemical and Metallurgical Engineering.

Maximum Rates of Water Consumption in Various Cities

It is found for any water system that there are certain maximum rates of consumption, monthly, weekly, daily and hourly, which are materially in excess of the average rates for the entire year. In order to design works to meet all conditions it is very necessary to take these maximum rates into consideration. In their recent report on the water supply of Kansas City, Mo., Fuller & McClintock, consulting engineers, gave the following table showing the percentage relation of rates of water consumption for the maximum month, week, day and hour to the average daily rate in various cities:

	Max month.	Max week.	Max day.	Max hour.
St. Louis	[illegible]		141	.
Cincinnati	[illegible]	[illegible]	111	
Cleveland	111		116	
Detroit	[illegible]		115	176
Buffalo	133	...	168	..
Columbus	[illegible]		137	..
Rochester			.	210
New York			.	175
Toledo	[illegible]		142	...
Grand Rapids	127	...	207	
Philadelphia	[illegible]	[illegible]	123	
Adopted for Kansas City	120	130	140	210

Method of Topping Out Germantown Hydraulic Fill Dam

The upper layers of the Germantown hydraulic fill dam of the Miami Conservancy District, Dayton, O., were constructed from a mixture of all borrow pit materials, deposited in a narrow center pool by the hydraulic method. How this was accomplished is told in the December Miami Conservancy Bulletin, from which the matter that follows is taken.

The final operations are indicated by Fig. 1, in which P represents the pool, BB the beaches, LL the levees and DD the dredge pipes bringing the water and suspended solids, at the stage when the dam had been built up to about elevation 815, 15 ft. below the dam crest.

The actual appearance of the dam at about this stage is shown in Fig. 2, taken from the south end of the dam, looking northward along its center line, Oct. 13, 1920. This was a late stage in the dam building (15 ft. from the top in a total height of about 106 ft.) The pool by this time was so narrow (about 15 ft. in width) that the transition zone unavoidably encroached on the true core zone, as was evident from the mixed clay and gravel in the nearest part of the pool. But the pool surface at this stage being about at the level of the assumed maximum flood in Twin Creek Valley (spillway level) the encroachment was not harmful, the mixture of coarser materials with the clay producing a "mud concrete" which is practically impervious under the low head of water which it will ever be called upon to resist.

In fact, in the upper layers of the dam embankment, at the elevation shown in the picture and above, the deposition of a true core was abandoned as unnecessary, and "mud concrete" was substituted. This had the advantage of providing also an immediate solid foundation for the roadway which is to be carried along the summit of the dam, connecting the roads on the north and south sides of Twin Creek Valley. This is the more desirable, inasmuch as the upper layers of mud, many feet in thickness, as deposited in the bottom of the core pool, are quite soft, and remain so for a considerable period.

The first stage, preparatory to the changed procedure, was to excavate the bottom of the core pool to a considerable depth along the entire length of the dam. The small dragline excavator seen in Fig. 2 is engaged in this operation, the materials "fished out" of the pool bottom being used to build up the two levees topping the side slopes of the dam. The levees at Germantown were thus carried approximately to elevation 825, about 5 ft. from the final dam summit, the pool bottom being lowered to about the depth indicated by the line AAA in Fig. 1. The object here was not so much to deposit the impervious mud concrete in the levees, as to mix the materials in the pool bottom, and break up any possible strata of pervious sand and gravel which might extend across the core, due to its narrowness at this elevation, and thus permit possible leakage through the dam.

Deposition of the mud concrete in the pool was then started, the materials being the same as those used to build the lower layers of the dam, and being pumped through a dredge pipe line in a similar manner, but with the use of one pipe line only. This pipe was carried nearly down the center line of the dam, discharging into one end of the pool, filling it up with the mud concrete to about the level of the line KK. (Fig. 1.) The position of the dredge pipe during this process is indicated by the small circle D'.

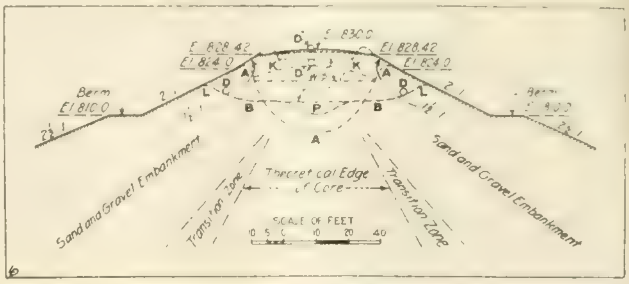


Fig. 1—Section Through Upper Part of Germantown Dam Embankment.

LL are the levees, BB the beaches, P the pool at the stage when the embankment reached an elevation of 15 ft. below the top. The pool bottom was then scooped out and built into the levees, giving the section AAA. Hydraulic fill was then deposited to the line KK. A repetition of these operations brought the dam to its final elevation.

The small dragline excavator followed the working dredge pipe along the dam embankment, digging out the central portion of the just deposited material, and casting it up on the two levees as before, carrying them thus to an elevation about 2 ft. above the ultimate dam summit. It dug in fact, a ditch, of which the two levees formed the upper sides, the object of this ditch being to retain the pool on the narrow summit of the dam for the deposition by the hydraulic process of the final batch of mud concrete necessary to top out the dam.

This final operation is shown in Fig. 3. The working dredge pipe is seen just to the left of and below the small dragline, discharging into the "ditch" just mentioned, filling it up with the mixed sand, clay and gravel. The dragline excavator follows just behind it, scooping out with its bucket such material as is necessary, and depositing it in front of

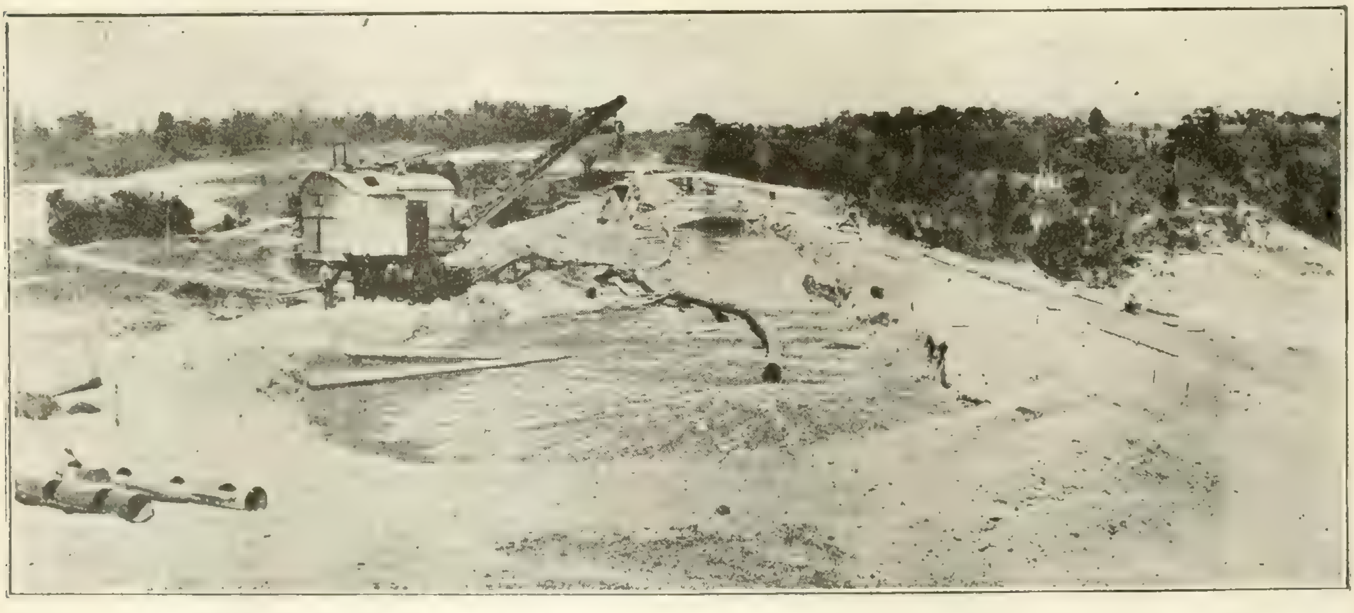


Fig. 2—First Stage of Topping Out the Germantown Dam; From Photograph Taken Oct. 13, 1920.

This was begun at an elevation about 15 ft. below the dam summit. The dragline excavator seen scooped the materials out of the bottom of the core pool and used them to build up the side levees, giving the section shown by the line AAA in Fig. 1. The main object of this deep digging out was to break up possible sand and gravel strata which might build out from the two beaches of the pool and permit leakage.

and behind the machine, wherever needed to bring the dam embankment to the proper level.

It may perhaps give reassurance to some who have had certain misgivings as regards the application of the method of hydraulic fill to the construction of the Conservancy dams, to observe in Fig. 3 the 40-ton dragline excavator (a No. 36 Marion machine) traveling along the surface of the dam summit and of the proposed highway, directly above the hydraulic fill core material which occupies the embankment interior below. Under this heavy mass the material showed no signs whatever of weakness or settlement. Levels taken on the finishing stakes on the dam summit two weeks after the completion of the embankment showed also no measurable settlement during this period.

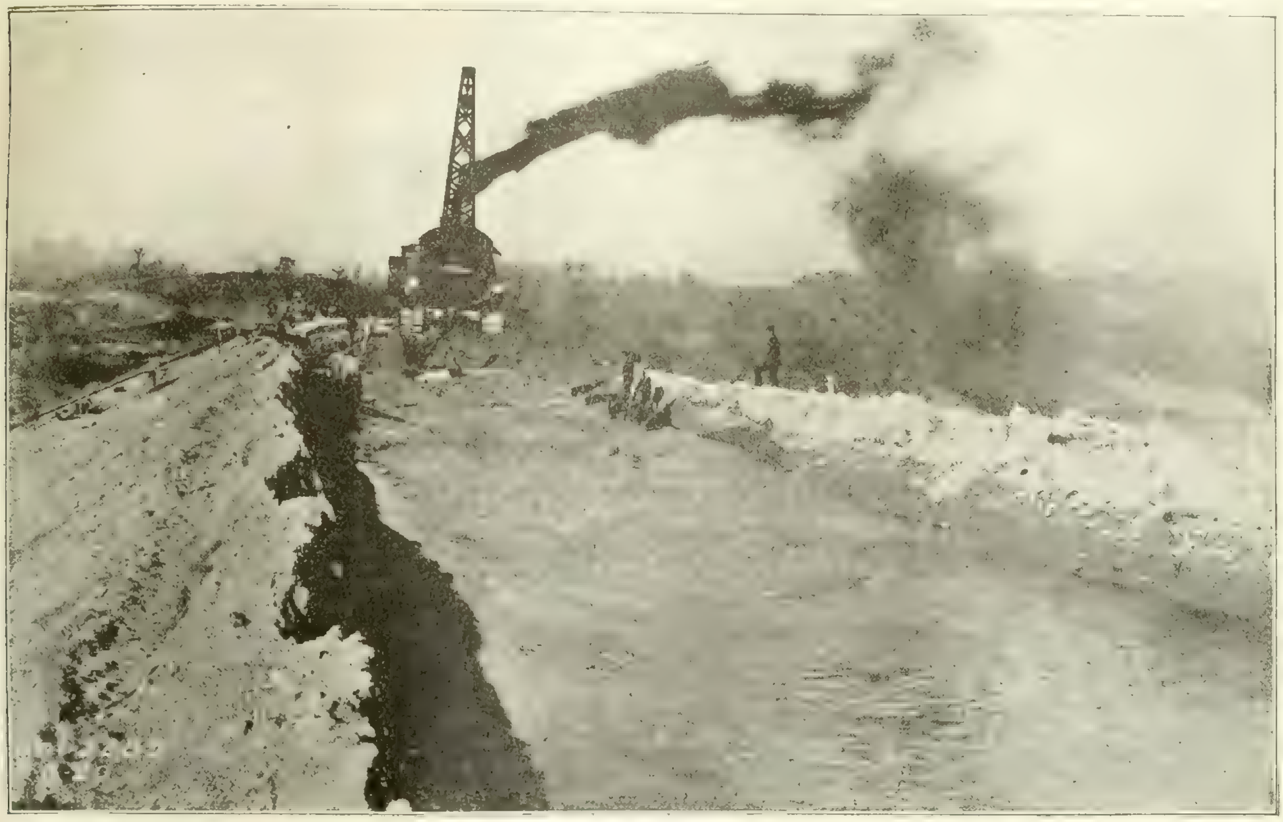


Fig. 3—Topping Out the Germantown Dam; From Photograph Taken Nov. 3, 1920.

Engineering Foundation and Industrial Research

Industrial research on a nation-wide scale, in which engineering organizations, universities, factories, individuals and private laboratories and other organizations are co-operating, is under way according to the recently issued annual report of Charles F. Rand of New York City, chairman of Engineering Foundation.

Describing the Foundation as a permanent national agency "for the furtherance of research in science and engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind." Mr. Rand outlined a broad field of activity in which the Foundation, profiting by the lessons of the war, is working.

Highway research, experimentation in the fatigue phenomena of metals, mental hygiene in industry, industrial personnel research, psychological tests for engineering students, industrial education in training, and tests of mechanical equipment are among the projects which the Foundation's effort embraces.

The Foundation, according to Mr. Rand, now has an endowment of $500,000. One anonymous gift of $200,000 has been received and one individual, it is stated, has offered to give $50,000 if nine other men would make equal gifts.

To avoid a possible deficit of $16,000 by 1922 Mr. Rand says Edward D. Adams of New York assumed this contingent liabiilty. Mr. Adams' liability has now been cancelled, the financial requirements for the work in hand having been provided by the increased income from endowment. The Foundation is raising a fund of many millions to promote industrial research in America and hopes this year to reach the five million dollar mark.

New $18,000,000 Water Supply Recommended for Kansas City, Mo.

Extensions and improvements to the waterworks of Kansas City, Mo., at an estimated cost of $18,000,000 are recommended by Fuller & McClintock, Consulting Engineers, New York City, in a report submitted to the Board of Fire and Water Commissioners of that city. The project includes a new intake at the Missouri River at or near the Platte-Clay County line in Missouri; new and extensive river protection work; a low lift and secondary pumping station and purification works located near the Platte-Clay County line; pressure tunnels connecting the new station with the present high lift pumping station at Turkey Creek and the proposed new high lift pumping station in the East Bottoms; a new high service pumping station on Nicholson Ave. The new supply works are planned to meet the needs of the city until about 1943, at which date it is estimated that about 700,000 people will be supplied.

The program of recommended new supply works is as follows:

An intake chamber on the river bank, together with necessary revetment works for protecting the banks and station conduits extending to the river pumping station	$ 1,013,000
A river pumping station containing pumping equipment and appurtenances for lifting the raw water from the river to the purification works and also for delivering the filtered water through a pressure tunnel to the city	1,300,000
Purification works, comprising grit chamber, reaction chambers, preliminary settling basins, coagulating basins, rapid sand filters and a filtered water reservoir, together with all equipment and appurtenances usual in a modern plant	4,485,000
A concrete lined pressure tunnel driven in solid rock from the Platte-Clay County site to a point south of the Missouri River with a branch tunnel to the Turkey Creek reservoir and another branch tunnel to the East Bottoms pumping station	1,471,000
A new high lift pumping station and equalizing reservoir at the site now owned by the Water Department in the East Bottoms	2,[illegible]14,000
Discharge mains leading from the East Bottoms station to the distribution system	2,400,000
Distribution system and improvement of existing works	1,600,000
Total	$17,983,000

Experiences at Grand Rapids, Mich., With Dorr Sewage Clarifier

Intensive operating studies of full size sedimentation unit have been conducted at the sewage testing station of Grand Rapids, Mich. The city's problem is one of plain sedimentation and sludge disposal, and efforts at the station have been directed toward the meeting of a state supreme court injunction, which calls for the removal of the sludge forming materials in the city sewage before being discharged into the local watercourse. The experiences at the station, particularly as regards the Dorr sewage clarifier, were recounted by Milton P. Adams, sanitary engineer in charge of sewage disposal studies, in a paper presented at the recent annual meeting of the Illinois Engineering Society. An abstract of the paper follows:

The city is sewered on the combined plan and has a normal dry weather flow of 30,000,000 gal. of sewage per day. The sewage of the city is discharged into the river at present through four main interceptors, two on the west and two on the east side of the river. These were completed in 1911 as part of a flood protection program, there being an average annual rise and fall of 16 ft. in the river stage. A flood relief pumping station is located adjacent to the outfall of each trunk sewer. Gates, coarse bar screens, and low lift centrifugal pumps are provided in each station by means of which the levels in the respective sewers are kept below the danger point during this high water period. It is planned that the permanent disposal plant will be out of operation during this time, the sewage being pumped directly to the river as at present.

Sewage treated at the experimental station is typical of 75-80 per cent of the total city flow and includes practically all the commercial and industrial as well as nine-tenths of the domestic sewage of the east side. From June, 1919, to March, 1920, the station was operated with the 32-ft. diameter tank as a Dortmund unit.

Sewage is delivered at the inlet trough of the primary tank by a 6-in. centrifugal pump belt driven from a 10 hp. motor. Due to intake troubles, the rate of flow would occasionally fall to 0.2 million gallons per day. The maximum rate was 1.1 and in the average day 0.6—0.8 million gallons of sewage were put through the primary tank. The flow was recorded hourly by the operator during the test day by reading the head over a standard rectangular V-notch weir placed in the effluent line from the tank.

Every effort was made to operate the station as a continuous day and night plant after Aug. 9, 1919. There was an operator in attendance at least 16 hours of each week day, and after the clarifier was installed, there was an operator in attendance constantly. In addition to the hourly flow readings, the operator made hourly settling solids and turbidity determinations on both crude sewage and effluent. Every third day, constant amounts from the hourly samplings were kept to form a composite of the day's run.

All samples and composites of sewage and sludge have been analyzed at the city laboratory located in the local filtration plant. This division of the work has been under the direct supervision of Chief Chemist Walter A. Sperry.

Results with the Dortmund Tank.—As the result of the experiments with the Dortmund tank, it was determined that 57 degrees was very close to the limiting slope which could be used and not allow lodgment of the sludge on the tank bottom. The 45 degree slope was never satisfactory even with squeegeeing to bring the sludge to the tank pump.

If for any reason sludge was allowed to accumulate, or was held in the Dortmund tank for more than ten days in warm weather, "tank boiling" invariably occurred. Masses of sludge varying in size from a teacup to a dish pan would be buoyed upward through the tank by entrained gas. They would suddenly appear at the tank surface, the gas would be released, the sludge mass break up—a part settling back into the tank and a part passing out over the weirs with the effluent. At times the action became very general over the surface of the tank. At these times the effluent and tank efficiency suffered severely. But the drawing of sludge would generally relieve this situation.

Considerable difficulty was occasionally encountered in starting a movement of sludge from the Dortmund tank. Back-flushing with city water pressure through the sludge outlet into the tank was resorted to. This clogging or sticking of the sludge in the outlet was not due to the character of the sludge alone, but to structural limitations of the outlet itself and occasionally to lodgment of foreign material in the outlet.

During the normal operating day the surface of the tank was clear at all times and presented a good appearance with practically no odor whatever.

During the nine months' operation of the Dortmund tank a total of 105 million gallons of sewage were treated with an average removal of 45 per cent of the suspended solids. Five hundred and eighty-three cubic yards of sludge were produced in the primary tank of an estimated average moisture of 93.5 per cent.

Description of Dorr Clarifier.—During April, 1920, a Dorr sewage clarifier was installed in the former Dortmund tank and operated until November last, when the station was closed down for the winter.

The second set of sedimentation experiments starting in May, 1920, were carried on with a 32-ft. Dorr sewage clarifier installed in the primary tank.

Nearly three carloads of cinders were required to fill the sump of the original tank, over which a 5-in. concrete slab was laid having the Dorr standard 1¾-in. on 12-in. slope toward the center. The central sewage depth of the new tank was now a little over 14 ft. with a depth at the periphery of the tank of 12 ft.

The Dorr apparatus can be briefly described as consisting of a centrally located vertical shaft to the bottom of which is keyed a 4-way spider to which radial arms are attached conforming to the slope of tha tank bottom. A series of parallel squeegees are set at an angle of 45 degrees with the line of each arm. These are so adjusted as to just brush the tank bottom when the mechanism is rotated. The entire mechanism is suspended from a superstructure which bridges the tank. The driving of the mechanism is accomplished by means of worm and gear. The speed of the installation was 3/50 r.p.m., and driven by a 2 hp. motor.

A watertight cylindrical wall of sheet steel, 4 ft. in diameter was fastened to, and supported by the four arms. It was symmetrically located with respect to the central shaft and turned as a unit with it. This original sludge well furnished by the Dorr Co. had a clearance of 5 to 6 in. from the tank bottom and extended to a point about 12 in. above the sewage surface in the tank. The rotation of the arms was designed to roll the sludge over and over coming in the path of the squeegees, and finally bring it within the central sludge well.

A circular, galvanized iron jacket surrounding the sludge well received the incoming raw sewage from the surface inlet trough. By means of a throat in the jacket converging to within 2 in. of the sludge well, a uniform distribution of sewage was obtained into the tank. The jacket was stationary and hung from the superstructure. It was 6 ft. in diameter at the top and 6 ft. deep, releasing the sewage in the tank 5 ft. below the sewage surface. The effluent was drawn off by a series of V-notch weirs set around the periphery of the tank. Thus so far as sedimentation goes we had a remodeled Dortmund tank.

Operations of Clarifier.—Operation was commenced May 15, 1920. First sludge appeared in the well on June 1st, and on the 2d, 16 cu. ft. of 92.6 per cent moisture sludge was removed from the well. Sludge was pumped every 2 or 3 days until the middle of June, when it became so concentrated that the pump would not handle it. The pump was a 2-in. diaphragm type furnished by the Dorr Co. Enough liquor was removed from the well during this period to allow it to re-fill with sludge.

We wired the Dorr Co. for help on the 9th, stating that the situation was getting beyond the control of our equipment, and within a few days they had an engineer on the job who, jointly with the writer, devised and built a mechanical sludge conveyor system. The conveyor was driven from the same countershaft which drove the clarifier.

With this apparatus, sludge was removed from the surface of the well by a chain of quart buckets, elevating to a tray, from which the sludge slid into a horizontal flight conveyor running in a wood trough. As the sludge approached the end of the trough, it dropped down an almost vertical chute into a loading hopper. Wheelbarrows were loaded with this sludge, and wheeled to the beds, where it was spread out to dry. The wheelbarrows were calibrated so that the amount of sludge removed from the tank could be recorded in this way. During a period of ten days in June, there was no movement of sludge into the well, that portion of sludge at the bottom and around the entry to the well took an "initial set," to use the concrete engineer's term, or concentrated to such an extent, that after the conveyor was put into operation, about 40 cu. ft. of sludge were all that could be withdrawn. The black, sulphurous smelling liquor remaining in the well could not be removed fast enough to force more sludge in.

Pumping of sewage was accordingly stopped and the tank was drained the first of July. After removing most of the sludge on the tank bottom it was discovered that an "island of sludge" had formed about the well which had been rotating as a unit with the mechanism. The entry to the sludge well was practically plugged.

During May and June, 24,000,000 gal. of sewage were passed through the tank with an average removal of suspended solids of 30 per cent corresponding to an indicated removal by settling solids determinations of 94 per cent. A total of 1,900 cu. ft. of sludge were produced with an estimated average moisture of 87.8 per cent. Of this amount 370 cu. ft. of an average of 90.2 per cent were actually removed at the surface by pump or conveyor.

In fairness to the Dorr clarifier as a sedimentation device, it must be admitted that sludge development and not sedimentation was the object sought during the entire 6 months' run. As a result there are but few periods when the tank had a chance to show what it could really accomplish. The normal week day tank efficiency under fair conditions of operation showed a per cent removal of 45 to 50 per cent.

The lowest tank efficiency generally occurred on Sunday when the suspended solids in the crude sewage would fall below those in the effluent for more than half of the day.

Changes in Sludge Well.—Mr. Peck of the Dorr Co., visited the experiment station about the middle of July, having been previously notified of the predicament the sludge had caused in the sludge well. He conceived the idea of flaring out the well at the bottom, which was intended to overcome our difficulty and accomplish the following ends:

Increasing the area of sludge opening into the well by making the opening equivalent in length to the circumference of a larger circle.

The storage and covering of a greater volume of sludge within the well would make for better conditions in the outer sedimentation compartment, as well as to give greater flexibility in handling of the sludge.

The concentration of as much evolved gas as possible within the well. The beneficial action of the gas in the 4ft. well had already been noted both from its buoyant effects on the sludge as well as the drying power it had exerted in passing through the upper layers of sludge.

Accordingly, the so-called "Grand Rapids" sludge well was constructed—a truncated cone of galvanized iron 10½ ft. high with a bottom diameter of 11 ft. and an upper diameter of 4 ft.

Provision was made at the upper diameter to attach one 4-ft. length of the 4-ft. well, bringing the upper rim of the composite well about 18 in. above the tank surface. The change increased the sludge well storage from 1,400 to 5,000 gal., and increased the area of sludge opening from 5 in. x 12½ ft. to 9 in. x 34½ ft.

Operation was resumed July 30 and continued with but two or three shutdowns until November 21. The first sludge was removed from the well on Aug. 24, and amounted to 47 cu. ft. of 67.5 per cent sludge. This was scum sludge, removed for the most part above the water surface in the tank, and was the dryest that we had obtained. All of the surface sludge had been removed by the 31st, several feet of black sludge liquor now appearing at the top of the well. This liquor was removed by a 4-in. Goulds diaphragm pump delivering 30-35 gal. per minute, and returned to the incoming sewage. About 4,500 gal. of liquor were removed from the well at this pumping, which allowed the well to completely fill with sludge from the tank bottom. Havoc was generally played with the tank effluent when this liquor or soft sludge was returned to the sewage inlet. The effluent cones would be darker than the raw sewage cones for several hours. The suspended solids and turbidities also ran much higher at those times than in the raw sewage, although the settling solids readings were not appreciably affected.

The station was closed the last of November, the primary tank being entirely open and exposed to the elements. The approaching cold weather also made the handling of the sludge at the surface with mechanical apparatus next to impossible. For a week or ten days immediately preceding the shutdown, vain efforts were made to fill the well with sludge. Several thousand gallons of liquor were pumped out of the well, but it was found by soundings that there was hardly sufficient sludge in the tank to trap the bottom of the well. Hence, it could not be expected that the well would fill with sludge.

It is tentatively planned to reopen the station in the spring applying the clarifier to a still shallower tank, reduce the sludge opening into the present well, and develop an underflow sludge delivery from the bottom of the tank. The sewage and liquor inlet to the tank will also be revised.

During August and September, the clarifier treated 18.5 million gallons of sewage with an average removal of suspended solids of 50 per cent. During the last two months of operation this figure fell to 24 per cent. From August to November 48.2 million gallons of sewage were treated in the Dorr Clarifier; 2,311 cu. ft. of sludge averaging 83.2 per cent moisture were produced. Of this amount 933 cu. ft. of 79.2 per cent sludge were actually removed by conveyor, the balance remaining in the tank at the end of the run.

Special Features of Clarifier Operations.—In commenting on special features of operation of the clarifier, probably that, which for lack of a better term, we have called "pin-point boiling" is the most interesting. The surface of the tank in operation represents any quiet body of water over which fine particles of sand are being sprinkled. This is caused by the bursting of minute gas bubbles at the surface. This gas is evolved in the sludge on the tank bottom and released by the periodical moving of squeegee arms through the sludge.

This is not our theory, but has been proven to be a fact, for on shutting down the mechanism in warm weather, this "pin-point boiling" stops altogether—the tank surface is clear for 8 to 10 hours while gas is collecting and being retained in the sludge below. Finally, enough gas is entrained to buoy masses of sludge to the surface where it is released—the action being identical with "tank-boiling" experienced in the former Dortmund tank. On shutting down for a few days in June, a 6-in. leathery scum of sludge formed over the tank surface in 24 hours. Thus, the necessity of the operation of some kind of agitator in a tank of the type in promoting good sedimentation is clearly evident.

Tiny globules of oil generally accompany these fine gas bubbles to the surface. It is this iridescent coloring of oil on water, which constitutes the only visible effects of this action. One half of the tank was baffled during the last three months of operation, the oil being caught just before passing out over the outlet weirs. As a result the effluent from this half of the tank was greatly improved although the appearance of the baffled half of the tank was accordingly sacrificed by the collection of the thin layer of scum retained upon it. It could not be proved that this "pin-point boiling" decreased the efficiency of sedimentation.

Characteristics of the Sludge.—The 80 per cent sludge produced during 1920 was a fairly stiff semi-solid and dried much less readily on the beds than the 94 per cent sludge of 1919.

The original Dortmund tank went into operation June 30, 1919. On July 25th, the first sludge was drawn from the tank through its sump outlet and delivered to a secondary tank.

Its tarry odor, brownish-black color, and curdy consistence, as we have since come to know them, were at once evident. Moisture determination ran 94 per cent. On Aug. 7 about 300 gal. of this sludge were allowed to run directly to the sludge beds from the primary tank. Eighteen days later, this same sludge was removed from the beds in pieces—a matted, porous, fibrous cake. After a few days' further drying, this sludge was burned in piles on the dike surrounding the beds. A fluffy, reddish ash was left behind. This performance was duplicated many times during the summer and early fall with the same favorable results. Contrary to the behavior of most sludges which fissure vertically in drying, this sludge seemed to dry in layers, separating laterally. Visitors at the station often compare the appearance of this sludge to that of heavy brown paper.

This very unusual behavior of a practically raw sewage sludge drying on sand beds under all sorts of weather conditions without nuisance or even appreciable odor, caused us to dispense entirely with secondary tank digestion during the past year. But two of the 20-ft. diameter sludge digestion tanks were ever used for this purpose. They were operated on the fill and draw principle. The same difficulty attended the drawing of sludge from the tanks as was experienced at times with the primary tank. Since there was so little to be gained by the use of secondary tanks they were abandoned with the idea that we would operate the station under the hardest conceivable conditions by drying a primary tank sludge on the sand beds and kick up a nuisance if possible! Well, we failed.

In addition to the many hundred gallons of sludge dried on the beds, thousands of gallons have been pumped from the tank at times of shut down, and allowed to drain to a low point 150 ft. south of the station, forming a lagoon. Visitors have never noticed the presence of this lagoon by reason of odors emanating from it.

Since we had precisely the same sludge experience during the past season that we had in 1919, and one that differs so radically from that in other cities, we have attempted to explain the mystery by a combination of circumstances.

First, we have a sewage that is comparatively dilute, amounting to more than twiçe the average water consumption. Thus the medium is provided by which many of the finely divided organic solids can be carried off in the effluent.

Secondly, the presence of tarry oils has always been noticed in the sludge. These are discharged in alleged small amounts by the local gas works. The antiseptic action of these light oils has long been recognized.

Thirdly, a large proportion of the sludge is made up of pulpy wastes, discharged into the sewer by a local paper mill. This material is practically inert and forms the fibrous mat which facilitates the drying and burning of the sludge. Samples of this dry sludge had a heat value of 7,000 B. T. U.

The ability of the sludge to "set up" when it is not periodically agitated was again manifested about the first of October, 1920. Instead of forming at the bottom of the well as before, several yards of the sludge formed a huge plug within the flare well, which threatened to put us out of business for a short time. Probing rods, long handled shovels, and 1½-in. pipes lashed to the superstructure and extending down into the sludge well were used from the surface of the tank in an effort to break up the plug, but without success.

It was broken up only after decanting off the upper 10 ft. of sewage in the tank, which allowed the plug to drop down within the well where it had a tendency to flatten out, spreading over the tank bottom. A 1¼-in. hose stream now helped in breaking up the mass. On refilling the tank with sewage, the plug came up again but much smaller in size. This was repeated three times before the plug entirely disappeared. After being broken up this sludge would appear in chunks rather than reverting to the homogeneous viscous fluid from which it formed.

Conclusions.—In concluding, it must be admitted that from the Grand Rapids standpoint with a sludge promising so little difficulty to handle, the high concentration is very desirable, especially where an almost unlimited space for sludge beds can be provided. There are 130 acres in the tract selected for the site of the permanent plant—fairly well isolated from the city.

There are several points still to be settled before final recommendations can be made. While much depends on the results of next season's experiments, the Dorr clarifier, in the opinion of the writer, has great possibilities. Compared with the Dortmund tank it has given practically the same sedimentation efficiency, and delivered much more concentrated sludge for at least six months in the year with but half the excavation required for the Dortmund. A strong point for the clarifier is the emulsifying and concentrating effect imparted to the sludge by the rotation of the mechanism. Over against these advantages are the greater depreciation in Dorr superstructure and mechanism and the greater expert attention required for the successful operation of a plant of this type.

Leaks in Watermains Under Railroad Tracks.—Several leaks in watermains at New London, Conn., last year occurred in places where the pipes passed under railroad tracks. According to the last annual report of the Water and Sewer Commissioner, the constant jar from the trains started the lead in the joints. Ball and socket joints will be installed at these locations.

Chemistry Explained: A Notable Book

By P. B. M'DONALD,
Assistant Professor of English, College of Engineering,
New York University

A new book called "Creative Chemistry" explains that difficult and multifarious subject, chemistry, as no other book has succeeded in doing. The many people who have wished for an understanding of the most ubiquitous of modern sciences can turn to this 300-page volume (published by The Century Co., 353 Fourth Ave., New York) and breathe a sigh of thanks to Doctor Edwin E. Slosson, the talented author. How any man could know so much about so many phases of chemistry, and then could explain it all so clearly and unpedantically is a marvel. Probably only a man who had been a professor of chemistry and had turned to editorial work on an important general periodical (as Doctor Slosson did) would have had the proper training for it. The book does not read like that deadliest of bores, a continual series of college lectures on chemistry in which terms are defined and experiments described. It discusses vegetal oils, synthetic rubber and plastics, metals, sugar, corn products, colors, perfumes, fertilizers, cellulose, nitrogen, poison gas, and the electric furnace, in a way that makes a reader believe he is conversing with a brilliant and well-informed friend. Seldom is there published a book which so well achieves that difficult requirement of the best writing on a specialized subject: that it shall be interesting not only to the specialist but also to the ordinary reader.

Even a numskull at chemistry, who cannot understand the cryptic diagrams of C's and H's that are supposed to explain organic chemistry, and who is overawed by combinations like sodium ditolyl-disazo-beta-naphthylamine-6-sulfonic-beta-naphthythylamine-3.6-disulfonate, can follow with interest Doctor Slosson's story of coal-tar colors or of the race for rubber. Incidentally he learns that the formidable compound mentioned above is a dye called Brilliant Congo and that the technical name is its formula; synthetic rubber, he also learns, can be made from potatoes, turpentine, sawdust, petroleum, coal and lime, or a plant found along the Mexican border, but none of these substitutes is entirely satisfactory as yet. The book recounts the fascinating tale of the invention of celluloid and bakelite. How an alert-minded young American printer named Hyatt noticed that collodion, which he tried putting on a sore finger, hardened when spilled on a shelf; how he mixed guncotton (the principal constituent of collodion) with camphor and got a new substance—celluloid. Now we have celluloid "ivory" and "tortoise shell" and "horn" and even "amber," "ebony," "onyx," and "alabaster." Bakelite, which we see in billiard balls, lacquer, pipestems, fountain pens, noiseless gears, etc., is another synthetic plastic. It is non-inflammable and has a high electrical resistance.

Other things which the engineering reader learns are: certain non-corrosive forms of iron such as duriron contain about 15 per cent of silicon; that the new "stainless" cutlery is steel having 12 to 14 per cent of chromium; that safes and armor plate can be cast from steel containing 11 to 41% of manganese for this alloy is too hard to be machined; that some of the new alloys for high-speed tools contain no iron at all but may be of chromium, cobalt and tungsten (stellite) or of nickel and zirconium (cooperite); that promising alloys are made by putting 5 to 10 per cent of mangnesium or calcium with aluminum, or a little copper, zinc, and tin with aluminum.

Contractors who have to feed large gangs of workmen should read the chapter on Solidified Sunshine and learn how healthful are certain vegetal and animal fats such as margarin, cottolene, crisco, and soy-bean oil. The sugars and corn products are given a chapter each, and their tremendous importance explained from a scientific point of view. Not since Count Rumford of the Holy Roman Empire, once a poor New England school teacher, reformed the dietaries of Munich, London, and Paris, has an American scientist written so convincingly on food. Under the magic guidance of this chemist-editor the reader sees how slight changes in H's or C's in a formula make alcohol out of sugar, or glucose out of corn, or acetic acid out of alcohol, and all sorts of finished industrial products out of sawdust, coal-tar, and wastes in general.

Run-Off from Underdrained Land and Action of Tile Drains on Ground Water Level

The designers of tile drainage systems are confronted with the fact that there is very little reliable information upon certain phases of underdrainage design and operation. To what extent do the character of the soil, the rate of lowering of the watertable, the size, depth, spacing and grade of the drains, the rate of run-off, the rate of rainfall, the climate and the topography enter into the successful working of a tile drainage system? The only way, apparently, to determine these questions is to make a study of underdrainage systems already installed and to apply the information obtained to the design of systems in areas of similar character. In a paper presented Feb. 16 at the third annual meeting of the Southern Section of the American Society of Agricultural Engineers, H. M. Lynde, Senior Drainage Engineer, U. S. Bureau of Public Roads, describes the method used and the results obtained in tile drainage experiments conducted on two farms in Northeastern North Carolina. His paper, practically in full, follows:

Naturally, much of the information used in the design of tile drainage systems has come from the Middle West, which is a leader in this form of agricultural improvement. To apply, however, the information gained in one locality to that of one remote from it, without a careful comparison of weather, topographical and soil conditions, is apt to lead to wrong assumptions.

For several years, in accordance with an agreement between the U. S. Department of Agriculture and the North Carolina Department of Agriculture, the Federal Department has maintained in North Carolina, a drainage engineer who is assisted by an engineer provided by the State Department, for the purpose of promoting the practice of farm drainage in that state. The work is both research and extension and covers all phases of agricultural drainage. Underdrainage has not been practiced to a large extent in that and other sections of the South, and there is great need and opportunity for experimental data on the subject, in anticipation of the time when tile drainage construction is bound to reach what may be termed the "popular stage," which now exists in the Middle West. It will probably be a long time before district land drainage by tile will be adopted, but many individual landowners are beginning to practice underdrainage.

The experiments were conducted on two farms in Northeastern North Carolina, for areas of 52, 23, 12, 10 and 7 acres, respectively, thoroughly drained by parallel laterals. The records from which the data were compiled and studied were kept by paid and careful resident observers, were continuous and cover considerable periods of time. On one farm, the records cover a period of three years, the work being discontinued about a year ago. On the second farm,, records have been kept for 20 months and the work is still in progress. The drainage systems on both farms were designed and installed under the direction of the above mentioned engineers and are situated on the comparatively level land of the Atlantic Coastal Plain. Other farms are being studied, but the work has not progressed far enough to present the data at this time.

Climatic Conditions.—The U. S. Weather Bureau reports summarize the climatic conditions of Northeastern North Carolina as follows:

The mean annual precipitation is about 51 in., the largest monthly amounts occuring in August and the least in November. The season of heaviest precipitation is summer with about 17.00 in., while the least is autumn, with about 10.50 in. The precipitation during winter averages 11.50 in., and during spring is about 12.75 in. The snowfall is unimportant and the rivers very seldom freeze over. The average number of rainy days is about 100 a year, the greatest number occurring in June, July and August, and the least in November.

Soil and Other Conditions.—The soils on the two farms were very different in character, but each farm is representative of a considerable area in the state. One farm represents conditions common to many of the second bottom lands along the rivers in the eastern part of the state. These soils are known as second terrace deposits, and are non-homogeneous and extremely variable in texture and mottled, beneath the surface. On the particular farm under investigation, in an area of 200 acres, 12 different soil types were identified, classified as loams, sandy loams, coarse sandy loams, fine sandy loams, clay loams, coarse loamy sands, coarse sands, and very coarse sands, of the four soil series known as Kalmia, Cahaba, Myatt, and Okanee. The surface color is generally gray to brownish, with subsoils of mottled gray, yellow, red and brown sandy clays and clays. The textures vary in short distances; in many instances, only 10 ft. separate one kind of soil from another extremely different.

The drains are laid on a minimum grade of 0.20 per cent (2⅜ in. fall to 100 ft.). The average depth is 3 ft., with a spacing of 60 ft. for laterals on one part of the tract, and 100 ft. on another. The joints between tile are unprotected against the entrance of silt. Two systems, draining 52 and 23 acres, were studied on this farm.

The soil on the second farm is Norfolk fine sandy loam bordering on Portsmouth fine sandy loam, and consists of a gray fine sandy loam topsoil about 12 in. deep, underlaid by a yellow fine sandy clay. It is homogeneous in texture. The minimum grade of the drains is 0.20 per cent, but most of the grades exceed 0.30 per cent (3⅝ in. fall to 100 ft.). The tile were covered with a layer of pine straw before backfilling. Three systems, draining 12, 10 and 7 acres, respectively, were investigated on this farm.

The Experiments.—The purpose of the experiments was to determine:

(1) Amount of run-off from underdrained land.

(2) Relation of run-off to rainfall.

(3) Action of tile drains in lowering the ground water level.

The run-off or discharge was measured by 90° triangular weirs installed in weir boxes at the outlets to each drainage system. Continuous records of the heads on the weirs were obtained by automatic water register clocks, fitted with seven-day charts. On the two farms, the five drainage units studied have separate outlets practically free at all times.

Daily rainfall records were obtained each morning for the preceding 24 hours by standard U. S. Weather Bureau rain gages, located near the centers of the tracts.

The groundwater level was determined by measuring the water level in observation wells installed at and between the tile in lines at right angles to the direction of flow in the drains. On the farm with a non-homogeneous soil, two lines of wells were also installed parallel with the drains, the purpose of which will be brought out later. In all, 152 wells were installed on this farm, while the farm with a homogeneous soil had 110 wells. The wells were 30 ft. apart where the lateral spacing was 60 ft., and 25 ft. where the spacing was 100 ft. In order to determine the shape of the profiles, some of the wells were spaced 10 ft. apart for short stretches. The distances from the top of the wells (the elevations of which had previously been determined) were measured each day for several days after a storm and two or three times a week during dry periods between storms.

Tables were prepared giving the discharges for different heads on the weirs reduced to inches in depth per 24 hours for each of the five drainage units. The discharges were obtained by scaling the heads on the weirs from the water register charts. The heads for each 2-hour period (into which the chart was divided) were scaled and added together, and the sum divided by 12, thus giving the main head for the day. From the tables, just mentioned, the discharge corresponding to this head was obtained. This discharge represented very closely the discharge for the day, except on days when the fluctuation in the head was large. On such days, the discharge was obtained by adding together the discharges for each two-hour period. The discharges were computed for the 24-hour period 8 a. m. to 8 a. m., in order to conform with the rainfall measurements.

The relations of the daily run-off to the daily rainfall were shown graphically on charts covering a period of one calendar year divided into months and days. The ground water profiles for several storm periods were plotted on profile paper. The object was to show the position of the ground water at its highest and lowest positions, and as many intermediate ones as could be shown distinctly.

Results Obtained.—Some interesting results were obtained. The experiments are still in progress on one of the farms, but enough data have been compiled and studied to show the trend of the results. Additional data will probably only strengthen the preliminary conclusions arrived at.

Groundwater Profiles.—Since the effect of the tile drains in lowering the groundwater level after storms is really the determining factor in the success of any underdrainage system, this phase of the experimental work will be discussed first, followed by a discussion of the rainfall and run-off.

Non-Homogeneous Soils.—During the three years that the experiments on the non-homogeneous second bottom land soils were being conducted, there were 11 storm periods which justified study, four in 1917, three in 1918, and four in 1919. The noticeable feature of the water profiles in these soils is their marked irregularity due to the variableness of the soil. Attention is called to Fig. 1, which is a short section typical of the profiles at right angles to the lines of tile. At first glance, it does not seem to indicate much of value, except that the watertable rises and falls under the influence of the rainfall. The curves certainly do not reresemble the generally accepted shape for curves of this kind. It is impossible to draw any definite conclusions from them, because the water level fluctuated so irregularly.

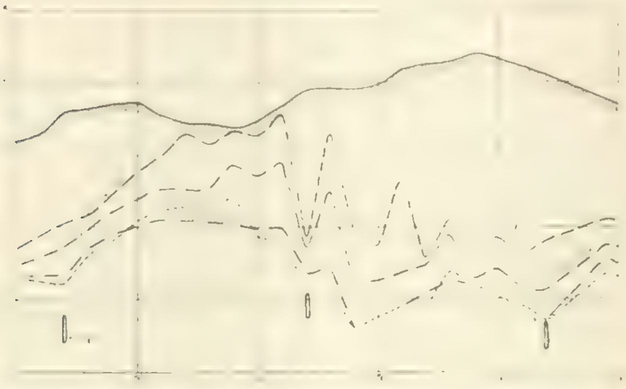


Fig. 1—Typical Groundwater Profiles Across Tile Drains in Non-Homogeneous Second Bottom Land Soils, North Carolina.

Figure 2 represents a short section typical of the groundwater profiles parallel with the drains. In a soil of uniform texture, it is to be expected that these profiles would be straight lines. As is apparent, however, Fig. 2 does not differ materially in appearance from Fig. 1. The irregularity of the profiles and the similarity of Figs. 1 and 2 indicate that the soil texture varies considerably in short stretches, and that groundwater profiles in soils of this character are unreliable for determining the average level of the groundwater or the correct depth and spacing for laterals.

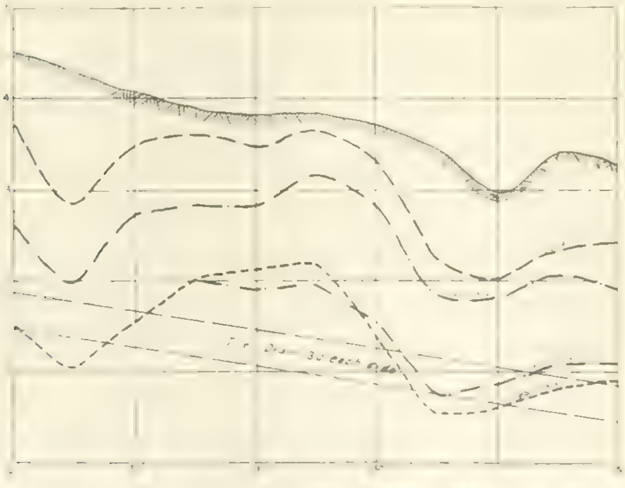


Fig. 2—Typical Groundwater Profiles Parallel With Tile Drains in Non-Homogeneous Second Bottom Land Soils, North Carolina.

Some parts of the tract are drained well, others apparently are not, because the water yielding capacity of the soil is deficient. To the speaker, these profiles indicate that the texture of the soil is the controlling factor in the efficiency of any underdrainage system.

Homogeneous Soils.—On the second farm, with homogeneous Norfolk and Portsmouth fine sandy loams, the data have been compiled and studied for a period covering only one year, although the experiments have been in progress to date, 20 months. During the first year ending June 30, 1920, the groundwater profiles were plotted for seven storm periods. Figure 3 represents a short section typical of profiles in these soils, which are open and of uniform texture. A study of all the profiles plotted indicates that within 24 hours after the soil is saturated to the surface between drains, the water will have fallen from 6 to 12 in. and that it takes from 4 to 5 days for the watertable to sink level with the drains. It is thus seen that the crops have a chance to recuperate from the effects of one storm before another occurs. The soil is sufficiently open so that the degree of drainage desired can be regulated by the spacing and depth of the laterals, as indicated by the V-shaped space, directly over the drains. The watertable has seldom risen more than a foot directly over the tile. Although it has reached the surface midway between drains in several instances, it has receded quickly from this position.

A study of the average of all the highest groundwater levels obtained to date indicates that no water appeared on the surface for a distance of about 20 ft. on each side of the drains. This would seem to indicate that if the drains had been spaced 40 to 50 ft. apart, at a depth of 3 ft., water would seldom rise to the surface between drains. On the other hand, if the drains were placed 5 ft. deep and 100 ft. apart, water would likewise seldom reach the surface, assuming, of course, that the soil texture remains the same. Reasoning along the same line, it seems probable that if the drains were spaced 125 ft. at a depth of 3½ ft., or 135 ft. at a depth of 4 ft., drainage equal to that of the present arrangement could be obtained.

Rainfall: During the three years the experiments were conducted on the first farm, 1917 through 1919, the daily rainfall was 1 in. or over on 35 days, 2 in. or over on 5 days, 3 in. or over on one day, and 4 in. or over on one day. The maximum daily rainfall recorded was 4.50 in.

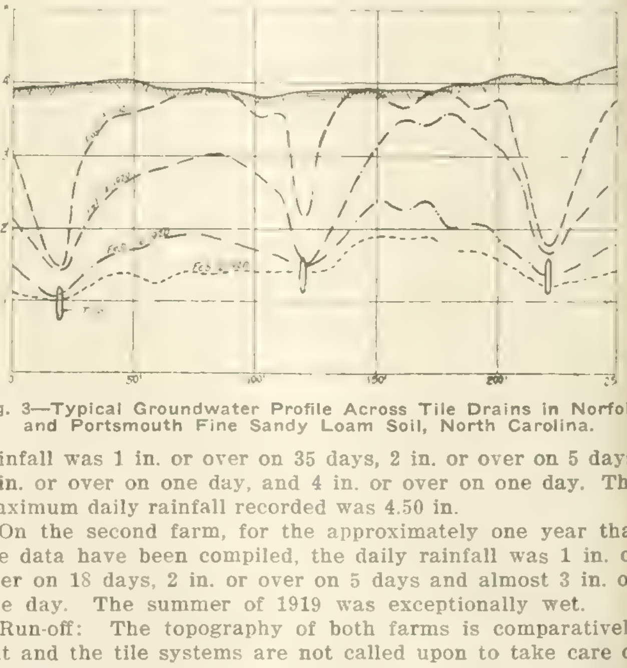


Fig. 3—Typical Groundwater Profile Across Tile Drains in Norfolk and Portsmouth Fine Sandy Loam Soil, North Carolina.

On the second farm, for the approximately one year that the data have been compiled, the daily rainfall was 1 in. or over on 18 days, 2 in. or over on 5 days and almost 3 in. on one day. The summer of 1919 was exceptionally wet.

Run-off: The topography of both farms is comparatively flat and the tile systems are not called upon to take care of any outside water. There probably is very little surface run-off so that practically all the rainfall passes off through the underdrainage systems. There are some breaks in the run-off records due to the fact that the automatic water register clocks occasionally got out of order, but it is believed that little data of value were lost from this cause.

Non-Homogeneous Soils: Taking the drainage unit on the farm with non-homogeneous soils which recorded the largest discharges, an analysis for the three years shows that the daily run-off was ¼ in. in depth or more on 12 days, ⅜ in. or more on 4 days, and ½ in. or more on 2 days. It is thus seen that the daily run-off exceeded ¼ in. on an average of only 4 days in a year. Allowing for brakes in the records, it is believed that it is safe to say the daily run-off never exceeded ¼ in. on an average of more than 6 days a year.

There were some peaks or flood run-offs at greater rates than the daily run-offs, but these lasted for only an hour or two, when there would be a sudden drop. In three instances, these peak rates exceeded ¾ in. The increase and decrease in the run-off was very rapid during and after a heavy storm. The flow often rose from a minimum to a maximum in a period of two hours' time or less, but fell somewhat slower, although usually within 24 hours after reaching the maximum. The maximum was reached some hours after the rain began. Large run-offs occurred at all seasons of the year and for rains of all intensities. The tile systems never ran dry, due undoubtedly to seepage water in the soil from adjoining high land.

Homogeneous Soils: On the second farm, the records for the first year indicate for the drainage unit giving the largest discharges, a daily run-off of ¼ in. or over on 23 days, ⅜ in. or over on 12 days, and ½ in. or over on 8 days. The drainage systems on this farm are dry for long periods at a time, and sometimes rains as large as 1 in. caused no flow. The summer of 1919, as previously mentioned, was extremely wet, and during one protracted storm period, when during 8 days 8.74 in. of rain fell, the run-off exceeded ¼ in. on 8 days in succession, ⅜ in. on 3 days and ½ in. on 2 days. About every three or four years, eastern North Carolina experiences a wet summer and 1919 was one of these years.

Studying the discharge records of both farms in conjunction with the groundwater profiles, it appears that the rate of run-off is but a measure of the rate at which the water moves through the soil to the drain. An interesting study would have been to compare the number of days on which a run-off rate of ¼ in. was exceeded on the two kinds of soils, for the same period of time, when all conditions were nearly similar, except the soil. By this means, the efficiencies of the drainage systems on both farms might be compared. If, for instance, the run-off exceeded ¼ in. on a certain number of days on the open textured soils, and a certain number of days (probably less) on the stiffer soils, and the drainage of the open soils be assumed as 100 per cent efficient, then the per cent of efficiency of the other soils might have been approximately determined. Such a comparison was impossible, however, for the only time such a comparison could have been made was during the wet summer of 1919, and the weirs on one of the farms were submerged part of the time.

As distinguished from the farm with a non-homogeneous soil, there were no extreme fluctuations in the discharges on the farm with an open homogeneous soil, and there were no peaks. Although the discharge increases very rapidly after a heavy rain to a maximum, it usually falls rather gradually at the end of the storm.

On both farms, the discharges for a few hours at a time were apparently larger than the calculated capacities of the tile mains (which were designed for a ¼-in. run-off using the Chezy-Kutter formula with $n = 0.015$).

Relation of Run-Off to Rainfall.—There seems to be no relation between the character of the storm and the run-off. The amount of rainfall rather than its intensity seems to be the determining factor in the amount of run-off. A thunderstorm will show an increase in discharge just as much as a rain covering a period of several hours, as near as could be determined. Many of the summer rains in North Carolina are thunderstorms and some of the largest run-offs were due to them.

Interpretation of Results.—Just how may the results be interpreted? Can any clean-cut or definite conclusions be drawn from them or is there danger in attempting to do so? In any set of data such as have been presented, certain relationships are bound to be obscured, and the conclusions arrived at can only be very general in character. In order to apply the results, it must first be decided in the experimenter's mind, whether the drainage systems are performing their functions well. The writer believes that they are so far as the engineering features are concerned, but no drainage system can carry off the water faster than the soil will deliver it to the drains. On both farms the drains appear to be able to handle the water as fast as it is received. There is some question in the writer's mind whether the non-homogeneous soils are of a sufficient water-yielding capacity to obtain the best results from underdrainage, although there is no doubt but that conditions have been greatly improved by its installation.

The results, as the writer sees them, may be briefly summarized as follows, bearing in mind that they can only safely be applied to areas where soil conditions, topography, rainfall and climate are similar:

(1) The texture of the soil is the controlling factor in the efficiency of underdrainage.

(2) In non-homogeneous soils, the spacing and depth of drains should be such as to suit average soil conditions as near as they can be ascertained, consistent with economy.

(3) In general, in non-homogeneous soils, laterals should be arranged in parallel, straight lines at equal distances apart and at the same average depth. For North Carolina second bottom lands of this character, a minimum spacing of 60 ft. and maximum depth of 3 ft. are recommended. It is not believed that the additional benefits to be derived from spacing them closer or deeper than these figures, will justify the cost.

(4) For Norfolk and Portsmouth fine sandy loam soils, with a surface slope exceeding 3 in. to the 100, a spacing of 125 ft. and an average depth of 3½ ft. are recommended for laterals. On slopes flatter than this, a spacing of 100 ft. and a depth of 3 ft. are recommended on account of the possible existence of basins and no surface run-off.

(5) The economic rate of run-off to be adopted in the design of underdrainage systems on areas similar to those investigated, appears to be ¼ in. per 24 hours if the Chezy-Kutter formula with $n = 0.015$ is used. This was the factor used in the design, and there seems no reason for increasing it, since the crops on the open-textured soil did not suffer injury and the surface water was removed quite quickly. Possibly for Norfolk and Portsmouth fine sandy loams with extremely flat topography, it may be advisable to provide for a ⅜-in. run-off, if the laterals are spaced closer than 100 ft.

(6) The grades of the drains on the two experimental tracts are 0.20 per cent or greater and are self-cleaning. Observations on tracts with similar soils where the grades are less than 0.20 per cent, appear to indicate that there is danger of silting in the smaller tile, unless the joints are protected, which may be done by wrapping with strips of building paper and covering with pine straw.

Engineering Advice on the Income Tax

The problem of figuring income tax returns for some of the large business houses is a matter of such technical intricacies, and involving such large sums of money, that it is of necessity given over into the hands of experts who prepare a report on the subject much as a lawyer prepares a brief. Usually these experts are specialists in accounting, or are lawyers who have focused their attention on this branch of law. There is a branch of this work which is distinctly the province of the engineer, however. Especially in cases where the element of depreciation enters in and a diminishing value of the property may affect the basis upon which the tax is figured, the questions involved are essentially those entering into valuation for other purposes than taxation. The possible savings or rebates upon past payments sometimes involve large sums of money, and are well worth the employment of an expert whose report, made upon an engineering basis, will have weight with the government department. There are, of course, economic problems which must be analyzed, just as there are such considerations in rate cases and other questions upon which an engineer must pass—and there are engineers whose special knowledge along these lines particularly fits them for this work. This a new field which has not yet been entered by the engineering profession, but one in which the engineer will find a legitimate and growing opportunity.—Editorial in the Journal of Electricity and Western Industry.

Rainfall Records at Providence and Pawtucket, R. I.—Precipitation figures as measured in Providence and Pawtucket, R. I., are given as follows in the recently issued 1919 report of the Waterworks Department of the latter city:

	Inches per annum.					
Location.	Mean for 35 years, 1885-1919	Mean for 19 years, 1901-1919	Maximum in 35 years	Maximum for 19 years	Minimum for 35 years	Minimum for 19 years
[illegible] Reservoir, Providence	47.40	45.13	63.50	58.42	36.38	36.38
Filter Fields, Pawtucket	.....	44.45	.....	51.26	....	36.86
[illegible] Building, Pawtucket	....	44.81	....	50.39	....	38.05
Pumping Station No. 3, Pawtucket	46.09	43.60	65.93	51.35	33.26	33.26
Diamond Hill Reservoir, Pawtucket	.....	44.20	.....	57.56	.	30.78

Some Observations Concerning Water Power

By J. W. LEDOUX

Consulting Engineer, [illegible]

[illegible] and the great difficulty of [illegible] fuel within the past two years have awakened many minds to the vital importance of the great subject of power production. It must be seen that it is only a question of a few generations when all the coal will be exhausted, as vividly described in Jules Verne's novel, "The Black Indies." It is probable inventors will find an adequate substitute long before the coal is gone. The problem is simply to discover a means by which the sun's heat is caught and stored in available form to be used as needed. The only practical method at present known whereby this is accomplished is in the organic cellular growth of carbon and hydrogen transformed from the inorganic carbonates, heat being stored during the process. Carbon is the main constituent of all vegetable growth, which can be burned to give off its heat to produce power in a more or less efficient manner. Vegetable matter will store this heat forever unless it is burned or decomposed by chemical or bacterial action.

In the formation of coal the deep beds of vegetable matter, beginning as we see now in dense swamps, were finally compressed successively into peat and coal, thus driving off the air and moisture, which form such a large proportion of the weight of vegetable growths, such as wood.

This is nature's slow process, but some time it may be discovered that a plant can be grown in one season in a sunlight region, and store sufficient heat from the sun's rays to supply the world's power requirements. However, this is speculative.

Last July an act was passed in Congress making an appropriation of $125,000 for a superpower survey, of which $92,000 was to be devoted to what is known as the Boston-Washington Zone. This survey contemplated the production of power in large plants located at favorable places, such as at the coal mines. Power would be transmitted to the various distributing points by electricity.

The survey was also to study the possibilities of water power development and determine suitable locations for dams on the various streams and rivers for the zones under consideration.

It is popularly believed that due to lack of foresight, there are permitted to go to waste many valuable water powers, which could be easily developed and save practically all the coal now used for power purposes. While there is a modicum of truth in this belief, the problem is not by any means as easy as it appears for several reasons. Most powers of consequence can be developed only at high cost. The power market has to be favorably distributed and within a reasonable distance from the development. Few individuals have the means for floating propositions of that magnitude, and therefore the aid of banking corporations and other capital controlling concerns must be solicited. Such concerns know, or are in a position to learn, of the many sad financial ventures that have been floated in recent years, and therefore refuse to consider a proposition unless the conditions are extraordinarily favorable to the underwriter. Knowing these difficulties and the sensitiveness of capital, many promoters, especially those who are not over scrupulous, prepare glowing prospectuses full of exaggeration and misstatement, and employ men with literary ability and enough technical knowledge to write good looking and favorable reports to accompany the prospectuses; so therefore when an unbiased report by an engineer of experience is presented, the average investor draws the conclusion by comparison that the project is not a good one. "The public likes to be humbugged," and many of these prospectuses and reports are based on that idea. The effect is to throw suspicion on good propositions.

But even at best there are drawbacks and difficulties to overcome, which can be appreciated by comparing a hydroelectric power proposition with one of the same magnitude and location based on steam power. With a steam plant there is only one serious difficulty; that is, the market and the load factor, which, of course, applies to the hydroelectric plant.

Having determined the amount of power, the maximum and average demands, the engineer has a choice of a large number of first-class firms who are expert engineers on their own equipment, and who are glad to give essential assistance to the designing engineer. The building, foundations, coal handling and storage, ash removal, heating, ventilation, pole line design and construction are all matters of well-known or easily determined detail. Even the location of the power plant is not difficult to determine, because if the conditions are not satisfactory at one place, another site can be selected, and the conditions governing the location are capable of determination by the exercise of ordinary intelligence.

But a hydroelectric plant is entirely different. The engineer is confronted with all the difficulties of the steam plant, which may therefore be eliminated from the comparison. Then we have those peculiar to the hydro-electric plant: How much water can be depended upon? The reliable answer to this involves a profound study of capricious nature and above all many years of experience, so as to know how much reliance can be placed upon published data, which for many reasons may be unreliable.

Even the law of probabilities is deemed by some engineers to warrant consideration in respect to the probability and duration of both maximum and minimum flows. The location of the dam is a matter of great importance, and the geological conditions have to be studied; the comparison of which is best: a long head race or a long tail race, or whether either of these should be in tunnel, or open conduit; character of dam, character of spillway, danger of ice, back-water conditions and property damage, amount of storage necessary and the consequent yield of water, the character of installation wheels, and the means of driving the dynamos, location of racks, head gates, necessity for surge tanks and their design, the consideration of the number and size of power units, the economical aspect of an auxiliary steam plant, the comparison of a hydroelectric plant with the most efficient heat plant that can be designed. All these and many other important questions must have consideration.

Let us take, for example, a water power on a steam having 2,000 square miles water-shed, on which there is an available head of 25 ft.: the first question to decide is how much water is available and what is its distribution? Let us assume that there are no continuous records of flow but only occasional measurements and no streams nearby under similar conditions whose flows have been recorded. The rainfall has been kept accurately for 30 years on various points of the water-shed, and varies from 60 in. to 25 in., and there have been continuous periods of five years where the rainfall averaged less than 32 in. per year. The problem is to find out how much power is available during every day for an average year. If no steam plant is to be considered, contracts for continuous permanent power can only be made on the basis of the minimum flow of the river, but the average flow may be 20 times the minimum flow, and the ordinary flow, such as can be counted on for 6 to 8 months of the year, may be 6 or 7 times the minimum flow. In order to have fairly definite information in these matters it is necessary to prepare a diagram showing the daily flow of the stream for an average year. With such a reliable diagram it is possible to tabulate the various quantities of power available for definite lengths of time, for instance:

Flows greater than the average last 20 per cent of the time.

Flows greater than three-fourths of the average last 30 per cent of the time.

Flows greater than one-half of the average last 60 per cent of the time.

Flows greater than one-fourth of the average last 80 per cent of the time.

Flows greater than one-tenth of the average last 95 per cent of the time.

The distribution will vary materially for different streams. A river like the Androscoggin, Maine, might yield three-fourths of the average flow for 90 per cent of the time due to the lake storage conditions on the upper part of the water-shed. On the other hand, for some of the southern streams, flows greater than the average might not last more than 10 per cent of the time; flows greater than one-tenth of the average 50 per cent of the time, and flows greater than one-twentieth of the average, 80 per cent of the time.

Such data are indispensable for making estimates of the power available under various conditions, and as there are no existing records of the stream itself, it is evident that the engineer must by some means obtain data for plotting the stream flow diagram.

Thirty years ago, the conventional method of doing this was to consider percentages of the rainfall, and in fact some of the best textbooks in existence at that time elaborated this method very fully, but as engineers gained experience, they soon found that this method was badly misleading, because streams continue to flow in the summer months, even when there is no rainfall, due to the storage in the ground, and the only time that the flow of the stream is approximately proportional to the rainfall is when the ground is full of water, or in this climate, during a period lasting from two to six months from, say, December to June. Sometimes a period of full ground water may last only two months in the entire year, and in some cases it may last six months, especially during a period when the rainfall is large and evenly distributed in the winter and spring months. During the balance of the time the flow of the stream follows a very complex law. The soil of the water-shed is saturated by the elevations of the water surface in the various walls on the water-shed; and the volume of water below this surface acts as a storage reservoir flowing into the stream at a rate depending upon the grade of this surface, character of the soil, and the consequent friction of the water passing through its interstices. If there were no rainfall during this period of draft on the ground storage, the flow of the stream would follow a definite law and could be predicted at any time with certainty depending upon the number of days which had elapsed since the ground was full of water. However, this principle is always complicated by the occasional rainfalls which occur during this drawing-down period, and there are other complications, such as the amount of water used by plant life; also the ice and snow conditions, which may nearly dry up the streams for a considerable period.

There is no consensus of opinion as to just the best method of arriving at the distribution of stream flow, but every hydraulic engineer has his own method based on his experience in the various localities in which he has practiced.

The U. S. Geological Survey and some of the states have accumulated and published a vast amount of stream flow data of great value to engineers, but in some cases the results are misleading, especially to those who have little experience. The measurement of stream flow is a difficult proposition, and in most of the permanent gauging stations the observations are entrusted to men of no particular training, who may not even appreciate the importance of reliable data. Their duties simply consist in setting down each day the elevation of the water as determined from the gauge board. From these results the flow is determined in the central office from a rating table prepared from stream flow measurements taken previously at different stages of the river. The gauging station may be prepared with the greatest care by experts, and yet it may be found that the subsequent results are in serious error. The cross section conditions may have been changed by accumulations of detritus, bars, or ice at various times of the year so that it is necessary for the engineer to supply some sort of a rough check in every important case, so as to determine whether and how much of the data can be relied upon. Rough approximation data is much more valuable than that which has every appearance of accuracy but contains fundamental defects. Take for instance the report of Geo. F. Swayne, contained in the U. S. Tenth Census on Water Power: here no attempt was made to obtain accurate data, but the judgment of the engineer was so reliable that this report is really a classic in stream flow estimation.

Then again, the rating of the gauging station may be in error due to several causes.

As an illustration, one of a number of instances may be given. The results of 25 years' observations of an important stream were published and used by promoters to exploit a water power project. The results looked unusually favorable for that locality, and hence a careful study was made of the monthly data as well as that upon which the rating curve was based. At the same time an independent calculation was made of the stream flow from the rainfall and other available data. The calculated flow was over 30 per cent less than the observed flow, and a close inspection of the distribution showed a fairly close agreement except for the winter months, during which the observed flow was far in excess of the calculated flows. The case was so important that a corps of engineers was sent to verify the rating curve and make a series of independent measurements of the stream. For this purpose a current meter was used and also several volumetric measurements made by means of salt. Some of the first results were obtained when the sides of the river were frozen, during which the observed flow in the accustomed manner gave results 30 to 50 per cent higher than the newly determined measurements. These comparisons were carried on for over a month and during the latter period when the ice was gone both sets of results agreed almost exactly. By using calculated results for December to March inclusive, and the state results for the balance of the year, the aggregate results for the 25 years agreed very closely with the calculated flow for the same period.

Where a river is cross-sectioned and measured at all stages during periods when there is no ice, and a rating curve, or table, is based thereon, the observations of the stage of the river when frozen will give flow results far too great, because the accumulation of ice at the sides and bottom of the river contracts the water cross section and raises the level of its surface. This phenomenon is important in cold climates, and there is no remedy except to make actual current meter measurements during ice periods, and if this is impracticable, the flow results should not be recorded for these periods.

There are some current meters which may be very reliable for steady flows but which are entirely unreliable when the flow is turbulent, and for this purpose the lightest and cheapest instruments obtainable may be the most accurate. On the other hand few current meters will operate where the velocity is much below 1 ft. per second, and at low velocities they are apt to be seriously in error, so it cannot be expected that the rating results are in all cases correct.

It is obvious that the most valuable water powers are those which are capable of delivering continuously the nearest to the maximum power which can be delivered at any time. This result is most nearly realized at places like Niagara Falls and the "Soo", (mouth of Lake Superior) where the volume of flow is equalized by immense storage, but the same result can often be produced on a stream by means of an impounding reservoir. To make available as a uniform discharge the entire flow of the stream requires in such climates as those of the middle and eastern states a storage from 15,000,000 to 20,000,000 cu. ft. per square mile of drainage area. This can be determined with accuracy by the use of the stream flow diagram, and for that purpose, what is known as the mass diagram is of the greatest utility.

Sometimes it is necessary to know how much power can be sold during the year with a plant of a given size, and where no material storage is possible. The procedure then is to utilize the daily flow diagram for the average year. A line is drawn across this diagram representing the amount of power installed; then it is evident that only those flows below the line are available for sale. These can be determined by adding up the annual amounts for each unit of time, or by the use of a planimeter, and if the power is graded and a different price estimated for permanent, secondary and other grades of power, the diagram will furnish the data for the determination of the probable annual revenue. This method is particularly applicable in these contracts whereby the consumer, usually a public utility, agrees to take from the Power Company at a fixed but low price per kw. hour all the power available at the power plant bus bar.

In some situations the greatest factor affecting the amount of power available is the elevation of the tail water, commonly referred to as "back water". That has been found in the great power plant at Keokuk on the Mississippi; and with such rivers as the Susquehanna, Potomac, Savannah and Chattahoochie, the effect of back water with low head dams may reduce the power available by 30 per cent.

The loss by back water can only be determined by an estimate of the cross section of the river for various rates of flow, and this is further modified by the consideration that when the dam is built, the water will be piled up higher at the base of the dam due to the reduction of velocity.

There is a phase of water power that has received too little attention. When a water power plant has combined with it a steam plant, it is customary to refer to it as an auxiliary steam plant, and its purpose is either to take care of the load peaks or the difference between that portion of the water power which is considered permanent and the maximum amount of water power available. Under these conditions the steam plant is working under the great disadvantage of a low load factor, which seriously reduces the economy, but if the steam plant is run at 100 per cent load factor the water power plant can be designed and run so as to take care of the peaks of the load, and the resulting total economy is very much better. This is only possible when the water power plant contains a material amount of pondage or storage.

How a Portable Mixing Plant Was Used in Constructing Duct Lines

When constructing the 6½ miles of 12-duct subway between Union and Passaic, N. J., and the 2¼ miles of 24-duct subway between Jersey City and Newark, N. J., the New York Telephone Co. was confronted with problems which compelled some changes in equipment.

The construction of the subways was of multiple duct tile with a concrete foundation and concrete top protection and all manholes were built entirely of concrete.

Mixing Plant Mounted on Truck Placing Concrete for Wire Ducts.

The road on the Union-Passaic job being very narrow and lined with swamps on both sides, the mixing of this concrete would have necessitated the building of platforms in the swamps for the mixer and material about 500 ft. apart and at a very high cost. A concrete mixing plant mounted on an automobile truck was the solution of this problem.

The outfit consists of a power batch concrete mixer mounted on a 7-ton Packard motor truck which was also equipped with two gravity hoppers, one for sand and the other for stone, in addition to a tank for water.

The materials for the concrete were gathered at a convenient place on the job and the sand and stone loaded into the hoppers by a Portable Machinery Co. scoop conveyor as shown in one of the illustrations. Bags of cement were also put on board. Fully loaded, the outfit carried material sufficient for 5 yd. of concrete.

Loading Aggregate Into Portable Concreting Plant.

The power mixer was fed by a laborer on the truck shoveling sand and stone from openings at the bottom of the gravity hoppers. The concrete was poured directly into the trench or manhole excavations by means of a spout. The truck driver, with a little practice, found it possible to regulate the forward movement of the truck to give the required thickness to the concrete in the trench so that little hand spreading was necessary.

The saving by the use of this equipment on this job was very great.

On the Jersey City-Newark job, although it was possible to mix the concrete in the usual way at stations along the trench, the use of the automobile mixer plant was found to be about 25 per cent cheaper than the fixed concrete mixing stations and the dumping of concrete into the trench and manhole excavations from wheelbarrows.

Concrete Sump Pit for Concreting Pumping Station Foundations

In constructing the sewage disposal plant for Dundas, Ont., a somewhat novel plan was adopted for concreting the foundations of the pumping station, which was located near a canal. The method employed is described by Mr. Geo. W. Sharp, superintendent for the contractors, in The Contract Record, from which the notes following are abstracted. The soil strata at this site was gravel and gravelly sand. At a depth of about 6 ft. seepage was encountered, which with sand was about to be troublesome, and it was decided that 2-in. close sheet piling should be driven and carried down with the excavation, so as to prevent the sand from running. From this depth down to the final depth the flow of water increased, until at 18 ft. it was found necessary to utilize two pumps, the first, a 2½-in. gas driven centrifugal pump, the second a 3-in. pulsometer. These two were kept busy handling the flow. Gravelly sand with a small proportion of clay, was found to be the material to receive the foundations, which was quite in accordance with test borings supplied by the engineer.

The flow of water at the finished excavated grade was very heavy and in order to place the concrete, a rather novel plan was adopted and carried out. A concrete sump pit was cast about 4 ft. square; this had walls 4 in. thick, with a 4-in. pipe cast in the upper side. Four openings, 4 in. square, were left in all of the four sides. This was lowered into a centrally located pit with a derrick. Lateral drains and branch lines of 4-in. field tile, with open joints, were laid on the bottom of the excavation, with sufficient grade to carry the water to the concrete sump pit. These drains were laid so to convey water from the points of greatest flow and connected to the openings in the sump, so that the water was delivered into the concrete box or sump. The sections between the drainage lines were filled with stone uneven in size so as to be quite porous. The whole bottom was then covered with a double thickness of roofing felt, well carried up the sides. The pulsometer pump was set into position, the suction being set into the pipe opening, in the upper side. The pump was put in operation and after the water had been lowered to the sump and the necessary adjustment made so that the flow was takn care of, concreting was commenced. Pumping was constant while concrete was being placed. When the bottom slab and first lift of the walls had been concreted, the pump was stopped and the water allowed to rise by way of the sump. This was left for several days during which time the whole excavation would fill. After concrete had sufficiently set, pumping was recommended, and the next lift poured and so on until complete. Upon the final lift being poured the pit was pumped dry, forms removed and a 4-in. cap quickly placed on the pipe in the sump and this concreted in.

Hydrated lime was used in the concrete which was 1:2:4 mix; the pit has shown no signs of leakage and is perfectly dry.

Beneficial Effect of Metering.—The consumption of water in New London, Conn., is measured by two Venturi meters, and, hence, their registry includes all water flowing into the city, whether used or wasted through leakage or otherwise, and all water used for fire extinguishment. The registry of these meters decreased from 1913 to 1916 and increased thereafter up to 1919. During the past year the consumption has been less by 84,484,250 gal. than the previous year. The present consumption, according to the 15th annual report of the Board of Water and Sewer Commissioners, is about the same as that of 1912, the same amount of water being used to supply the present estimated population of 26,000 as was required for 19,000 in 1912.

St. Lawrence River Project Promises Benefits for New England

Projects now under consideration for the improvement of the St. Lawrence River as a waterway and, at the same time, for the development of large quantities of power, will benefit the New England States many times over in the way of cheaper power to replace expensive coal and the removal of heavy, bulky materials now hauled by the railroads for very low rates. This is the viewpoint taken by Henry I. Harriman, member of the Massachusetts Commission on Foreign and Domestic Commerce, in a paper recently presented by him before the Boston Society of Civil Engineers, from which the following is extracted.

Conservative estimates indicate the possibiilty of developing 4,000,000 HP., equivalent to the energy produced from 24,000,000 tons of coal burned in the most modern and efficient steam plant, or of 36,000,000 tons burned under the boilers of the average New England mill. The total energy entitled to the United States is estimated at 13,000,000,000 kw. hr., of which the New England States should be entitled to about 6,000,000,000 kw.-hr., or about one-fourth of the whole.

Considering the power requirements of New England, the utilities today are generating about 2,000,000,000 kw.-hr., but it is fair to assume that fully one-fourth of that power now comes from water, and therefore we may assume that the utilities can use about 1,500,000,000 of this St. Lawrence power. The railroads should be and will be electrified in the near future, and there are 5,000 miles of arilroads in New England. But 1,500 miles of railroad transport 80 per cent of the tonnage of New England railroads, and so it is only necessary to electrify about 1,500 miles of road in order to handle the great bulk of the railroad tonnage of this section.

The railroads of New England are using about 6,000,000 tons of coal a year, and if 80 per cent could be replaced by electric power, it would be true that electricity was replacing about 5,000,000 tons of coal. That coal last year cost New England railroads nearly $50,000,000. If they had bought St. Lawrence River power at 1 ct. per kw. the cost of energy represented by 5,000,000 tons of coal would have been about $18,000,000—a saving of nearly $30,000,000—and a few years' saving would have paid for the electrification of those 1,500 miles of road, including the purchase of the locomotives, track structure and substations. If that saving had been effected it would have been equal to 3 per cent on all of the outstanding bonds and stocks of all the New England railroads.

There are many pieces of track that will probably never be electrified, but those 1,500 miles that bear heavy traffic will, in Mr. Harriman's opinion, be electrified; and, when they are, the St. Lawrence River can be assumed to supply a sufficient energy to operate them. That would take another 2,000,000,000 kw. So the railways, electric light companies, trolleys, etc., would out of 6,000,000,000 kw.-hrs. take about $3,500,000,000. That leaves a balance of 2,500,000,000 for industry. Let's see what the demands of New England industries are. I have absolutely no authentic information on that. The number of spindles in New England cotton mills is approximately 18,500,000—22 spindles per horsepower being a fair allowance. The number of spindles in the woolen mills is 2,199,999, with 4,200 cards, probably requiring about 200,000 HP. The cotton mills now use about 1,000,000,000 kw.-hrs., and about 25 per cent of this now comes from water. The woolen mills require not over 175,000,000 kw.-hrs. Without going into the details of the other industries, like paper, brass, rubber and machine shops, I think it is fair to say that 2,000,000,000 kw.-hrs. would be all the power generated by water that New England industries now require, and therefore the St. Lawrence power would be sufficient to supply our railroads and utilities and industries and still leave us one-half billion kilowatts to draw on.

Considering the effect upon the railroads themselves, the objection has been raised that they will be the losers. In answer, traffic is doubling every 15 years. It will be at least 10 years before this project is finished. It will be the heavy materials that will be taken from the railroads and put on the boats, and instead of a detriment to the railroads it will be a help to them. President Smith of the New York Central believes it will save them millions and millions of dollars in investment in terminals and tracks, if the bulk of the heavy traffic, which pays relatively poorly, is taken from the railroads and they are left to carry that class of material which pays them a better rate.

New Filtration Plant for Palm Beach, Florida

A 3,000,000-gal. per day water filtration for Palm Beach and West Palm Beach, Florida, has just recently been completed and placed in operation by the West Palm Beach Water Co., which supplies both towns. We are indebted to Mr. George W. Simons, Jr., Chief Sanitary Engineer, Florida State Board of Health, for the following particulars regarding this installation:

General View of Filter Units. No Shelter Over the Units Is Provided Because of Favorable Warm Weather the Year Round.

The water supply comes from Clear Lake, outside the city limits, and is very soft but also highly colored and, at times, the presence of algae growths give the water undesirable tastes and odors. The object of the filter plant is to remove the color and the objectionable tastes and odors.

The installation consists of aeration and coagulation basins, filters, filtered water reservoir, together with a low-lift and a high-lift pumping stations. The water is pumped by the low-lift pumps through the aerating nozzles of special design and falls into the first passageway of the coagulating basins. It receives the coagulant prior to aerating, so that mixing is done by means of the spray effect. There are two coagulating basins each with a capacity of 500,000 gal. and three around-the-end type of baffles. The coagulated and settled water flows out of the basins through shear gates directly onto the filters.

Type of Aerator Used. All Coagulated Water Is Sprayed Into Large Coagulating Basins Through Nozzles.

There are six filters, located just south of the coagulating basins each with a capacity of 500,000 gal. per day, and are 12 ft. by 15 ft. in plan. The filtering media consists of 30 in. of sand and 18 in. of graded gravel. The underdrain system is of the Harrisburg type [illegible] of 1½ in. diameter laterals spaced on 9 in. centers with 16 in. perforations every 9 in. The laterals are [illegible] into 6 in. cast iron collectors which are brought together underneath the filter [illegible] pipes.

The filtered water reservoir is a covered concrete structure with a 7 ft. depth and a capacity of [illegible],000 gal. It has a groined arch roof and an inverted groined arch floor, and is covered with 1 ft. of earth.

In connection with the filtration plant is a small laboratory fully equipped and with constant supervision.

The plant was designed by Hazen, Whipple & Fuller, of New York, and was approved by the State Board of Health in October, 1919. The plant is said to have cost about $125,000.

Evaluation of Waterworks of Rockford, Ill.—The total value of the entire property of the Water Department of Rockford, Ill., according to an evaluation Dec. 31, 1920, was $1,170,866. The various items are given as follows in the annual report of the Water Department for the year ending Dec. 31 last:

	Items.	Original cost.	Life, years.	Present age.	Total present value.
P1	Distribution system, 741,422.8 ft...	....	..	..	$ [illegible]68,601
P2	Pumping pit and infiltration well.	$ 3,633.00	..	..	....
P2	Shaft and tunnel system..........	46,132.00	50	22	35,410
P2	Water piping and appurtenances at central station, including conduits, etc..........	7,569.00	50	20	5,994
	Conduit improvements, 1920......	2,645.99	50	0	2,645
P2	Reservoir No. 1 (1883, rebuilt 1913)	18,891.96	50	7	17,157
P2	Reservoir No. 2 (built 1912).......	19,662.75	60	8	18,643
P2	Wells, at Plant and Peach St.....	26,500.00	..	29	7,500†
P2	Well No. 7, 18th Ave. and 11th St.	10,301.47	40	7	9,532
P2	Well No. 8, Hulin Park..........	10,488.49	40	4	10,120
P3	986 fire hydrants	73,274.16	40	22	55,466
P3	Drinking fountains, water tanks and street stand pipes..........	....	..	..	1,362
P4	Hand tools and tool equipment...	....	..	..	2,958††
P5	Motor driven deep well pump No. 7	7,724.80	20	7	6,663
P5	Motor driven deep well pump No. 8	[illegible]	20	1	5,211
P5	[illegible] air compressor, 1920	[illegible]	[illegible]	0	22,921
P5	10 in. Venturi meter, Well No. 8	[illegible]	40	1	537
P5	Snow engine, 10 million gallon capacity	[illegible]	40	[illegible]	30,017
P5	Holly-Gaskill engine, 6 million gallon capacity..........	26,851.00	30	28	5,000†
P5	Holly-Gaskill engine, 3 million gallon capacity	13,864.00	20	27	1,200†
P5	Mead system—				
	Engines and condensers	[illegible]	20	22	2,500†
	Pumps and discharge..........	13,351.00	20	22	3,500†
P5	Impeller pumps—Wells 3 and 5....	6,736.00	10	9	.......*
P5	Steam pipings	2,545.00	20	25	180†
P5	Boilers—return tubular—2—old...	10,800.00	20	19	2,700†
P5	254 h.p. water tube boiler—1918..	11,623.96	20	2	10,851
P5	Recording instruments, boiler meter, boiler feed pump, 2 stoker engines, ash conveyor, 1 6-in. Worthington meter..........	2,011.00	15	19	350†
P5	Sirroco fan—Well No. 8..........	122.00	40	4	116
P5	Remote control—wire for well No. [illegible] inventory ..	[illegible]			430
P5	Wagon scales, central station [illegible]	[illegible]	[illegible]	[illegible]	292
P6	Transportation equipment—inventory				[illegible]
P7	Other equipment inventory				5,12[illegible]
P8	Buildings—central station........	28,677.00	50	30	19,171
P8	Buildings—well No. 7...	[illegible]	[illegible]	[illegible]	1,189
P8	Buildings—well No. 8 .	[illegible]	50	4	7,856
P8	Reinforced concrete stack........	5,422.00	60	13	4,302
P8	Water works shop	[illegible]	40	23	2,583
P9	Real estate—central station site .	15,000.00			75,000
P9	Real estate—2 Highland lots......	1,400.00	..	..	1,650
P9	Real estate—2 lots well No. 7 site	1,429.38	..	..	1,650
	Total property evaluation Dec. 31, 1920..........				$1,170,866

*Abandoned. †Fixed. ††Inventory.

Water Consumption at New London, Conn., from 1911 to 1920.—The following table from the report of the Water and Sewer Commissioners of New London, Conn., for the year ending Sept. 1, 1920, shows the water consumption per inhabitant and per consumer, and percentage of meterage since 1910:

[illegible]	Gallons per each inhabitant	Gallons per consumer	Per cent consumers metered
Sept. 1, 1911..........	141	151	35
[illegible]	134	[illegible]	[illegible]
Sept. 1, 1913..........	135	159	[illegible]
Sept. 1, 1914	149	154	40
[illegible]	131	[illegible]	[illegible]
Sept. 1, 1916..........	111	[illegible]	[illegible]
Sept. 1, 1917..........	111	104	74.5
Sept. 1, 1918..........	127	99	58
Sept. 1, 1919..........	131	123	69.3
Sept. 1, 1920..........	119	117	75

Control of Flood Flows in Drainage Ditches by Low Dams

The construction of low inexpensive dams to control the run-off in a drainage area so as to deliver a fairly constant flow to the drainage ditches was suggested by Thorndike Saville, associate professor of hydraulics and sanitary engineering at the University of North Carolina, in an address before the 10th Annual Drainage Convention. Mr. Saville pointed out that it was rarely economical to design a drainage ditch to carry the absolute maximum flood which occurs only once in a number of years, since the cost of infrequent repairs is in this case less than the cost of a larger cross-section; and stated that instead of spending money enlarging drainage ditches to take occasional floods, or in repair of ditches damaged by floods would it not be best to so control the run-off on a drainage area as to deliver a fairly constant flow, or at least a flow which shall not surpass a certain predetermined amount? It is at least economical for us to expend a sum on the construction of flood control devices, the interest on which would serve to keep in repair and maintain drainage ditches injured by floods. Usually much more may be properly expended on flood control, since drainage systems frequently cause increased frequency and magnitude of floods in districts down-stream, and claim for damage may result. With the present high cost of labor it becomes increasingly desirable to make drainage ditches as nearly as possible of only sufficient size to take the normal flow and to prevent erosion of these by flood flows.

Further notes of his address follow:

The problem is to so regulate the discharge of flood water to a stream that it will rise only a predetermined amount beyond its normal level. For this purpose it is necessary to study the catchment basins of the tributary streams. It is necessary to know their rate of flow in flood, the time interval which their flood crest takes to reach the main stream, and the effect of the various tributary floods on flood crest in the main stream. It is when the flood crests from a considerable number of tributary streams reach the main stream at nearly the same time, that great floods result. Often by straightening and widening channels the delivery of flood waters from some tributaries may be hastened and the flood in the main stream reduced in magnitude. Since the total amount of water to be delivered is not greatly affected by such measures, the duration of flood in the main stream will be extended, though its magnitude is decreased.

When the measures noted in the preceding paragraph are ineffective or impossible to achieve, it becomes necessary to construct retention reservoirs. By this is not meant necessarily the creation of large impounding reservoirs by high dams. It is frequently possible on small streams to erect low dams on the tributaries, such that the flood waters may simply be retarded to a sufficient degree to prevent simultaneous discharge of flood crests to the main stream. In many instances in drainage projects it is possible to place one or more such barriers on the main stream itself. The construction of such retention basins is probably best affected by a somewhat similar procedure as is being applied on a large scale in the Miami Conservancy District near Dayton, O. This method consists in constructing retarding basins at selected points on the tributaries and main stream. In the case of drainage districts served by a "flashy" stream, a low dam may be located at an appropriate place with a culvert opening in it. During normal flow the culvert discharges the waters of the stream as if no dam were there. During flood flow the discharge of the stream increase beyond that for which the culvert is designed and water is impounded behind the dam. The culverts then discharge under a hydrostatic head and are so designed that they will deliver water at such a rate as to keep the height in the main stream below a predetermined level. As the flood flow decreases the culverts continue to discharge until the impounding basins are empty. Such a scheme may be quite inexpensive as compared to elaborate construction of levees and increased size in ditches and canals to take the flood flow.

The suggestions in the preceding paragraph relate primarily to the construction of low inexpensive dams to create retarding basins. A similar control of floods may be obtained by the construction of higher dams creating large storage reservoirs. Here the reservoir may serve the double purpose of flood regulation and power development. Such structures are relatively expensive and are economical only under conditions of good dam site, fairly large normal flow of the stream, and a market for the power. There are doubtless some situations in North Carolina, particularly in the Piedmont District, where such developments would be profitable. The utilization of our smaller waterpowers is becoming increasingly important, especially in the cheap production of electric power for promoting conditions in the rural districts equal in convenience and comfort to those in the city. The coordination of waterpower developments and flood regulation in drainage districts is one of the more practical means of meeting this problem.

Arc Welding Outfit for Tapping Water Mains

To avoid the necessity of shutting the water off from customers who require it continuously for irrigation, the city of Los Angeles has turned to the use of an arc welding outfit for tapping mains. The arrangement is described in the Journal of Electricity, from which the following illustration and information are taken:

The set consists of a portable direct current generator driven by a gasoline engine, the whole mounted on a motor truck.

Heretofore the practice has been to parallel the larger mains with smaller ones which could be shut off and emptied in order to make service connections. This was expensive and often it was necessary to shut off the mains up to 72 in. in diameter, drain them, with a loss of a large amount of water, and then make the service. Under the system now in effect the welding outfit is taken to the job and makes the connection in four hours' time, thus making a great saving in time and material.

The procedure is to turn down in a lathe and grind on an emery wheel the size of pipe desired. The end of the pipe is polished for 2 in. and beveled to an angle of 60°. When taps to small diameter mains are to be made the service pipe is ground to fit the curvature of the main.

Before starting the job of welding the main is polished with an emery wheel to effect an easier bond. The coupling is then spot-welded and the first layer of metal applied. Considerable skill is required in handling the arc when depositing the first layer, but successive layers can be put on quite easily. The hole in the main is made in the usual way.

Portable Arc Welding Outfit for Making Connections to Water Mains.

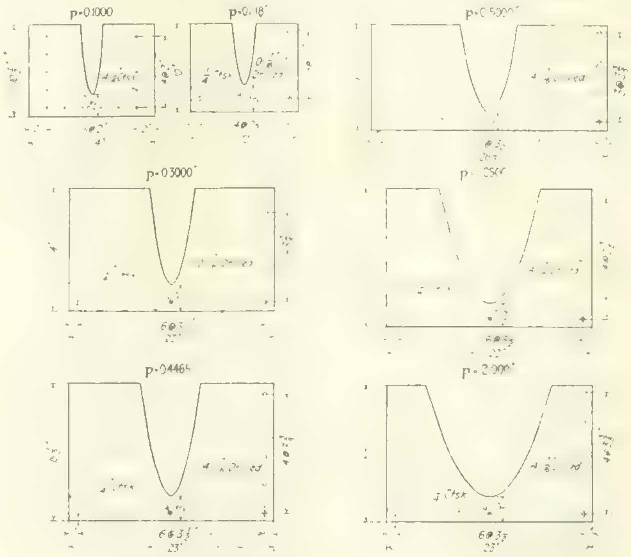
The welding unit consists of a 20-kw. direct current generator driven by a 6-cylinder gasoline engine which also drives an air compressor which supplies air for testing the connection after welding. The engine is supplied with a special governor to give the requisite steadiness in voltage. The panel on which switches and controls are mounted is built up on a small platform supported on wheels so that it can be taken to any desired part of the work.

The outfit was developed by S. B. Brown, an electrical engineer of Los Angeles.

Parabolic Weirs

A series of experiments on parabolic weirs at the Hydraulic Laboratory at Purdue University show that this type of weir is one of the best developed and permits the use of a comparatively simple and accurate recorder for measuring the discharge of a given stream. The discharge may also be computed from a very simple formula, varying with the square of the head on the weir.

The parabolic weir is the invention of Mr. C. Lauritson, of the Ohio Body & Blower Co., Cleveland, O. Calibration tests were made on seven different weirs and extended over a period of 9½ months. A description of the tests and the results of the experiments appear in a paper by F. W. Greve, assistant professor of Hydraulics, Purdue University, Lafayette, Ind., prepared for the American Society of Civil Engineers, and issued by that society in pamphlet form in January, 1921. The following is an abstract of the paper:



Parabolic Weirs.

The weirs are designed according to the equation of the parabola $x^2 = 2py$, and those tested are designated according to the value of p in this equation.

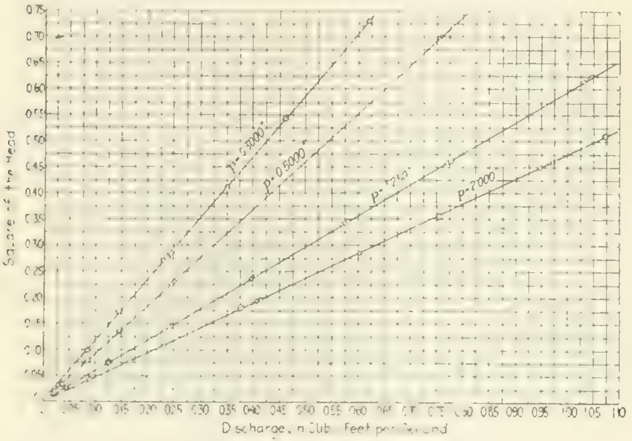
The values of p for the seven notches are 0.1000, 0.1118, 0.3000, 0.4465, 0.5000, 1.250 and 2.000 in., respectively. These figures will be used to designate the notches, which were cut in ⅛-in. brass plates, with the exception of No. 0.1000, which was formed from a 1/16 in. plate. The weirs were fastened to a heavy wooden frame set across the end of the channel.

Description of Apparatus.—Weir No. 2.000 was the first to be tested and was placed at the end of the concrete channel, 5 ft. wide, the crest elevation being 4 ft. 8 in. The elevation head was measured by both a piezometer and a hook-gage. Readings could be noted to 0.001 ft. by means of verniers. The piezometer was connected to the channel by a ½-in. pipe, the entrance to which was flush with the interior face of the wall, within 6 in. of the bottom and 9 ft. 8 in. up stream from the weir. The hook-gage was suspended from an overhead grader the same distance from the weir as the piezometer. A calibrated stop-watch was used to determine the time. The flow was provided by either a 2-in. 60-gal. per minute triplex pump or a 6-in. 1,800-gal. per minute centrifugal unit, according to the quantity desired. The water was pumped through a 6-in. pipe, provided with a valve, to the concrete channel at a point 40 ft. up stream from the weir. The flow in the channel was over an 8-ft. suppressed rectangular weir and through two baffles. Zero head was noted on the gages when the water surface was level with the lowest point of the notch as ascertained with a spirit-level.

All weirs other than No. 2.000 were placed at the end of a wooden channel, that was 7 ft. 9 in. by 3 ft. 10 in. in plan and 2 ft. deep. The channel was constructed of smooth cypress planks, 1½ in. thick, and properly caulked to prevent leakage. The cross-sectional area could be changed by adjusting the false sides and bottom. Water entered the channel close to the up-stream end through a 3-in. connection to the 6-in. main. To allow the water to enter the channel with the least possible disturbance, the lower portion of the inlet pipe was drilled full of ⅜-in. holes. Two baffles were used to provide a smooth water surface.

The piezometer connection was a ¼-in. pipe, its entrance set flush with the inside face of the channel at a distance of 18½ in. up stream from the weirs and 2 7/16 in. below the level of the crest. The crest is herein defined as the lowest point of the notch. The hook-gages were attached to rigid supports and were placed midway between the sides of the channel. Hook-gage No. 1 was 4 ft. 5½ in., and No. 2, 18½ in. up stream from the weirs. The discharge was weighed in a tank of 20 tons' capacity.

How the Tests Were Made.—Weir No. 2.000 was first placed in the large channel before being beveled. The gage readings for zero head were noted when the water level in the channel was brought up flush with the bottom of the notch as indicated by a straight edge and a spirit-level. The pump was started, and the flow through the weir was wasted through a valve in the bottom of the weighing tank until the head had become steady as shown by the gages. The waste valve was then closed and the time noted for a predetermined rate of discharge. At least three readings of the gages, and frequently more, were made for each run or test, the length of the test being measured by the watch and determined by the time required to pass the quantity of water indicated by the change in weights. The usual practice throughout the investigation was to make two or more runs for each head. The weir was then removed, beveled, replaced and tested under the same conditions as just set forth.



Relation Between Discharge and Head.

The other weirs were installed in the small channel and tested in the same manner as Weir No. 2.000. Weirs Nos. 0.1000, and 0.1118 were calibrated with the edges both beveled and unbeveled.

A mechanism, devised by Mr. Lauritson to record the total quantity of flow through a notch, was attached to the side of the channel at a point 4 ft. 5½ in. up stream from the weir. This mechanism was actuated by a float attached to a shaft by a rod. Fastened to the other end of the shaft was a pointer that was caused to move across the face of the dial as the shaft rotated due to the motion of the float. The principle is simple. The pointer is set at the center of the dial for the position of zero head. The float will rise with increase of head, causing the pointer to move outward. The distance traveled by the pointer can be made proportional to that through which the float rises with the aid of a properly designed link. The cross-sectional area of the stream in the plane of the weir will vary as the square of the head which is also the square of the distance through which the float rises. The area of any circular disk with its center on that of the dial will vary as the square of the radius. The square of the head and the square of the radius are proportional to each other. Therefore, the area of any portion of a circle described by the pointer is proportional to the area of the stream in the plane of the weir, both being dependent on the square of the head. Mr. Lauritson has also invented an automatic integrating attachment for the recorder which makes unnecessary the use of a planimeter on the chart. This latter attachment is somewhat novel in design in that areas are integrated directly. The rate of flow through the weir can be observed on the chart and the total amount can be read directly on the integrator.

Computations of Rate Discharge.—The actual rate of discharge can be computed by the formulas:

$$q = kh^2, \text{ and}$$

$$q = C \frac{\pi}{4} \sqrt{2g} \sqrt{2p}\, h^2$$

where q is the actual rate of discharge, in cubic feet per second; h is the elevation head, in feet; k is a constant for any given weir with beveled notch; C is the coefficient of discharge; $\pi = 3.1416$; $g = 32.16$ ft. per second; and p is a constant in the equation of a parabola, $x^2 = 2py$.

The relations of the coefficients k and C to the head are constant for any given weir with beveled edge; at least, for heads of 0.15 ft. and greater. They are variable for weirs with unbeveled notches, increasing with decrease of head.

One of the most valuable features of the parabolic weir is that the value of k can be predicted for any given value of p according to the following formula, the graph of which on logarithmic paper is a straight line:

$$k = m (\sqrt{p})^n = 0.1798\, p^{0.4787}$$

The following table shows the variation of the coefficients k and C with p for the seven weirs with beveled notches:

No. p, in inches.	√p.	k.	C.
0.1000	0.3162	0.500	0.615
0.1118	0.3344	0.533	0.619
0.3000	0.5477	0.852	0.605
0.4465	0.6682	1.01	0.588
0.5000	0.7071	1.10	0.605
1.250	1.118	1.69	0.588
2.000	1.414	2.11	0.585

The following table is a recapitulation of the relations of the coefficients to p:

The values of C and K were computed from the equations

$$K = \frac{\pi}{4} \sqrt{2g} \sqrt{2p}; \text{ and } C = \frac{k}{K}.$$

$$q = k h^2 = C \frac{\pi}{4} \sqrt{2g} \sqrt{2p}\, h^2 \quad Q = K h^2 = \frac{\pi}{4} \sqrt{2g} \sqrt{2p}\, h^2$$

No.	p, in inches	k	K.	C
1	0.1	0.502	0.813	0.617
2	0.2	0.700	1.15	0.609
3	0.3	0.850	1.41	0.603
4	0.4	0.976	1.63	0.600
5	0.5	1.09	1.82	0.600
6	0.6	1.19	1.99	0.597
7	0.7	1.28	2.15	0.595
8	0.8	1.36	2.30	0.592
9	0.9	1.44	2.44	0.590
10	1.0	1.51	2.57	0.587
11	1.25	1.68	2.88	0.585
12	1.50	1.84	3.15	0.584
13	1.75	1.98	3.40	0.583
14	2.00	2.11	3.64	0.581

Conclusions.—As a result of the experiments, the writer has reached the following conclusions:

1.—The parabolic weir is one of the best types yet developed and is adaptable to a wide range of conditions.

2.—By means of a parabolic weir, the actual rate of discharge can be computed by the very simple formula:

$$q = k\, h^2$$

where q is the actual rate of discharge, in cubic feet per second, h is the elevation head, in feet, and k is a constant for any given weir with beveled notch. Values of k are given in Tables 3 and 4.

The actual rate of discharge can also be computed by the equation,

$$q = C \frac{\pi}{4} \sqrt{2g} \sqrt{2p}\, h^2$$

where C = the coefficient of discharge;
$\pi = 3.1416$;
$g = 32.16$ ft. per second;
p = variable in the equation, $x^2 = 2py$;
h = elevation head, in feet.

3.—The parabolic weir is adaptable to a simple and accurate device for recording the discharge.

4.—The values of the coefficients can be accurately predicted for any given value of p.

It should be emphasized that: (a) Beveled notches and thorough baffling are essential; (b) the velocity of approach should not exceed 0.5 ft. per second.

Convention of South West Waterworks Association.—The convention of the South West Waterworks Association will be held May 9-12 with headquarters at the Skirvin Hotel, Oklahoma City, Okla. E. L. Fulkerson, Waco, Tex., is Secretary of the association.

An Engineer in the President's Cabinet

What the Newspapers Think of Hoover's Appointment as Secretary of Commerce

In imposing conditions upon his acceptance [illegible] of commerce Mr. Hoover lets a breath of fresh air into the musty room of reported cabinet "deals" and "arrangements." Mr. Hoover says to Mr. Harding in effect that he has no desire for a seat at the cabinet table as such. If a place there can be utilized for the performance of real achievements, of the style to which Mr. Hoover has been accustomed, he is willing to think it over. Even so, he must be left free to finish his great task of feeding Europe.

The spectacle of a man laying down terms regarding his entrance into the cabinet will make senators gasp. They know how they would treat such impertinence. But it will only make the country more eager to have Hoover in the cabinet and it ought to have the same effect upon Mr. Harding.—New York Evening Post.

Herbert Hoover thinks the Department of Commerce can be made to live up to its name without the necessity of any special legislation. Thus far the department has never seemed able to run in high gear. It is a nest of technicians, statisticians and other domestic pets of low blood pressure, but has developed no ambitious program for going after world trade. It has neither been practical nor executive. The name of Hoover will give it a billion dollars' worth of advertising to start with. To the whole world it represents something more than the Yankee idea of barter. Hoover wishes America to prosper, but not entirely at the expense of the rest of the world. They can all advance together, according to his way of thinking. A world's clearing-house of commodities is likely to develop through the Hoover genius and initiative. It could be made the greatest stabilizer of the time and an effective buffer of Bolshevism.—Los Angeles Times.

Although the department of commerce is one of the new departments and has never attracted much attention, the moment Mr. Hoover is mentioned for it suddenly it becomes the star department and everybody begins to speculate on its possibilities. Mr. Hoover has much of the talent of Mr. Roosevelt for always sittting at the head of the table no matter where his seat may happen to be.

Without any question Mr. Hoover is sincere in urging upon Senator Harding a much larger field of activities. His decision to remain at the head of the foreign relief work is wise. His duties will not only not conflict, they will run together and he will make of the department of commerce a means to help the world as well as to encourage trade with America.

But the net result of the discussion, just when curiosity is on tip toe with regard to the new cabinet, is to very greatly stimulate interest in Mr. Hoover's part, and very greatly to magnify the significance of his selection. Senator Harding issues almost an emergency call to Mr. Hoover, and Mr. Hoover takes up this work after getting a free hand.

It is inevitable that a man of such talent will be one of the star performers in the coming four years, and at the head of a department that has to do almost wholly with foreign affairs, he will bring to Secretary Hughes of the state department just the sort of aid that will enable him to dominate the foreign policy of the administration. And Mr. Hughes is not wanting in a certain sort of self-confidence that makes his seat always a seat at the head of the table.

It is unlikely that Mr. Hughes will again be considered for party leadership. But he is not yet 60 years old, and defeated candidates have been renominated in times past. But Mr. Hoover is only 47 years of age, and his future is wholly before him. Mighty few men in the world's history, at his age, have done what Herbert Hoover has done, and mighty few have gained so much worldwide attention. Mr. Hoover has health, he has brains and energy, and he has the genius of Roosevelt for attracting attention.

For many reasons he is bound to be more and more the central figure of the administration. It is a safe prediction that from the formal indorsement of the cabinet appointment by the senate to the end of Senator Harding's term Hoover will be the storm center, just as at his age Roosevelt was the storm center. The future of Hoover becomes one of the big speculations in American politics.—Des Moines Register.

There is a good deal to what Mr. Hoover says about a man's opportunity to make his own job. Some are [illegible] to let them be what they will (and jobs generally prefer to be small), and some never quit until they make them big and important. Mr. Hoover thinks he can make the secretaryship of commerce a worthwhile job, and from what his countrymen know of him they will agree that if it can be done he is the kind of man to do it.

The country has not regarded the commerce department as a particularly big job, but maybe that is because it never had a particularly big man at the head of it. Nobody ever told the country it stood for anything except a seat in the cabinet. * * * * * *

Mr. Hoover make it fairly plain that he does not regard a cabinet post as a door through which he may be expected to step to a comfortable oblivion. The commerce department as at present organized probably is not altogether attractive to a man who stood up to the job of feeding the world after the armistice and found it about his style in point of activity. But instead of rejecting the opportunity as being too unpromising to engage his energy or zest, Mr. Hoover closes with it with the notice that he expects to make it worth buckling down to. It is all rather inspiring. Why, a man like that probably could make something of the vice-presidency even. * * * * * *

The country is ready to take Mr. Hoover at his word. It is willing he should make the commerce department anything he thinks it should be, for it knows enough about him to know his efforts will be in the direction of making his office yield public service. The department that gives the most of that is the biggest department in the government no matter what the name may be, and the secretary that produces those results will be assigned his proper rank in the cabinet.—Kansas City Star.

Hoover is a broad-head, a business man plus scientist, and a good one both. He will make an impression in the government and leave his mark on the history of the time. Politicians have no reason to fear him if their political activities are for the public good.

Both Hughes and Hoover in the cabinet may be said to represent the general public, no other basis of consideration being necessary in their selection, their ability and technical adaptation of the task at hand being universally accepted.—El Paso Herald.

Mr. Hoover will be a member of the cabinet of Mr. Harding. This fact will cause general satisfaction. Mr. Hoover has said that he has dedicated his life to the public service. The only question that has evidently been in his mind has been as to what is the best channel for the exercise of his undoubted talents. * * *

Mr. Harding has apparently been surprised that there has been so much talk about Mr. Hoover's position. There have been statements regarding "stipulations" under which Mr. Hoover would consent to join the official family of the new President. Probably every other man who has been invited into the official family has conferred, at least in a general way, with Mr. Harding concerning his duties as a member, and this evidently is what Mr. Hoover has done, though more mention has been made of it. At any rate, all that is necessary is the coming President's statement that he and Mr. Hoover are in accord. As Secretary of Commerce, Mr. Hoover will have a wide field, and a field for which he is peculiarly suited to display his abilities.

The Harding administration in a broad sense is to be an administration of reconstruction, and therefore the post of Secretary of Commerce is one of the most important. The task is that of upbuilding, and Mr. Hoover will be at home.—Wilmington Evening News.

And there's Herbert Hoover! If there's a job in all the world too hard or huge for him to master, there are very few folks in all the world who would be willing to believe it on anybody's mere assertion. They would first have to be shown. Even those who would have preferred to see somebody else in his cabinet job would hardly have the nerve to brand Hoover as a "disappointment."—Springfield, Mo., Republican.

Herbert Hoover has accepted a cabinet position. Mr. Harding is to be congratulated. While there are a great many reasons for believing that this country is not headed straight for revolution and disintegration, it must always be remembered that Herbert Hoover is one of the reasons. * * *

Herbert Hoover enters the cabinet at a time when a cabinet office cannot in any way add to his standing. He is already an international figure. In fact, in Europe he is an inspiring legend. In his profession Mr. Hoover ranks as high as Charles M. Schwab ranks in his. Hoover could have anything he wanted in the business world; and yet he goes into the cabinet in order that he may render a public service. When Mr. Hoover gets to operating, congress may not agree with him; the people as a whole may not agree with him. He may find that even he cannot reorganize the department of commerce to the extent he desires. Nevertheless, in everything Mr. Hoover will do, service will be the first consideration. Hoover is not a politician. He is an extremely able man, who, instead of selling his ability in the market to anyone of a hundred corporations that would purchase it, accepts a cabinet job at a cabinet officer's salary.—Johnstown Democrat.

Experiences in Chlorination of Florida Public Water Supplies*

By GEORGE W. SIMONS, JR.,
[illegible] Florida State [illegible].

Liquid chlorine is very effective in small doses. Analytical data available indicates that it is a strong bactericidal agent. The average dose for a clear water is usually about 0.20 p.p.m. Race states that the dosage is largely regulated by (1) the content of readily oxidizable organic matter, (2) the temperature of the water, (3) the method of chlorine application, and (4) the contact period.

The average dosages used by several Florida plants are shown in Table I.

Chlorine has an affinity for organic matter, therefore a water highly colored or containing a great percentage of organic vegetation matter will consume more chlorine in the oxidation process.

In doses generally used there is little chance of tastes or odors, yet such complaints are quite common. It has been stated that a dosage to about 1.0 p.p.m will not cause a taste or odor. Many complaints are due to autosuggestion. The most recently developed way of regulating the proper dosage is by a chemical means—by administering chlorine to the water in slight excess and detecting the presence of free chlorine within a few feet of the point of application. Small kits are now made up for making such free chlorine tests.

As shown in the table there are nine chlorination plants now operating on public water supplies in Florida. In addition there are several at Government reservations and private estates. All such plants are chlorinating deep seated waters excepting those at Orlando, Palatka and West Palm Beach. The plants at Jacksonville and High Springs are of recent installation, in operation less than 6 months. At St. Petersburg the chlorinator was installed as a positive protection and insurance against any possible contamination of the deep supply; likewise the installations at Jacksonville and High Springs.

During the late part of 1919 the State Board of Health passed a regulation requiring all chlorinating plant operators to submit daily operation reports to the State Board of Health. Such records were received throughout 1920 from every plant. They not only give the amounts of daily pumpage at the plant, but also the amounts of chlorine added daily, and the operation difficulties encountered. After keeping a set of records for 12 months and tabulating same, it was apparent that the plants were not giving the best service they should and could. An investigation instituted revealed several important troubles:

(1) Clogging or stoppage due to formation and accumulation of a yellow gum-like substance in various parts of the machine, due to impurities in the chlorine.

(2) Corrosion of various parts of the apparatus.

(3) General neglect of the apparatus; too much dependence being placed in its automatic operation.

(4) No stocks of extra parts on hand with which to make small repairs and corrections at times of trouble, with result that parts would necessarily have to be shipped from the factory.

To insure a proper operation of the apparatus the temperature of the room or compartment in which the chlorinator is located should not be excessive. When chlorine cylinders become warmer than the apparatus the chlorine will distill over and condense on the apparatus and interfere seriously with its proper operation.

The location of the chlorinating apparatus and cylinders in highly heated boiler or pump rooms should therefore be avoided. To Sept. 4 the chlorinating plant at St. Petersburg was out of commission 50 per cent of the time; trouble with stoppages and the formation of yellow gummy accumulations on the apparatus were noticeable. An investigation found the apparatus and cylinders in a pump room having high temperature and humidity. Later the apparatus with cylinders were placed outside the pump house in a small specially constructed shelter having a more even and lower temperature, with the result that the plant has operated every day since without interruption.

The plants at Miama and West Palm Beach are likewise located in small structures detached from the hot humid pump rooms, with the result that neither plant is ever out of commission. A room temperature of 80° F. or less is satisfactory for cylinders and apparatus.

Great care must be exercised in getting a good quality of chlorine free from impurities. Accumulations due to impure chlorine can be successfully eliminated by washing with carbon tetra chloride. Leaky apparatus have given rise to corrosion at points of connection—such leaks can be easily detected by fumes of ammonia; leaks should be repaired immediately to prevent unnecessary corrosion. To better control dosage and check operation, platform scales should be available to correctly weigh the chlorine consumed each day; no such scales are at the Live Oak and High Springs or Palatka plants.

The point of chlorine application is of importance. In Florida and at a majority of the plants, the chlorine water is applied to the suction main of the pumping units. This seems to be the best and proper place to get the most effective mixing and results. At West Palm Beach and Orlando the chlorine is applied subsequent to the filtration process.

At all plants equipped with chlorine apparatus a move is on foot to provide duplicate units to care for periods of repair. Recently such units have been installed at Miami, St. Petersburg and Jacksonville. All plants should also keep on hand a full line of repair parts and connections.

The experience with the Florida units during 1920 emphasizes that every operator should be more particular as to the care of the several units at all times to prevent unnecessary stoppages and troubles. The plant operators must come to the realization that a chlorinator is a mechanism demanding attention. The automatic feature and satisfactory operation of the plant will be fully realized when the operator's brain functions. Prompt attention to leaks, replacement of worn and corroded parts, and temperature control are absolutely necessary to success.

To treat with chlorine a water which to all intents and purposes is absolutely pure and wholesome seems foolish to many, yet water is easily contaminated and capable of becoming infected. Therefore at a nominal cost of not more than $1 per 1,000,000 gal. doesn't the chlorination of a public water supply and its protection against chance contamination seem like a safe and reasonable investment for any community?

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50 Years' Service as Engineer and Superintendent of Waterworks.—"As Mr. Walter H. Richards is this year rounding out nearly half a century of faithful and exceptionally efficient service as Engineer and Superintendent of the Water and Sewer Departments, the Board takes occasion to renew its expressions of its high appreciation of the unusual quality and value of his services to the Board and to this municipality."—From the 1920 report of the Board of Water and Sewer Commissioners of New London, Conn.

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*From a paper presented Feb. 21 before the Florida Engineering Society.

TABLE I. LIQUID [illegible] DOSAGES AT SEVERAL FLORIDA WATERWORKS

City.	[illegible] million.	Pounds per million gallons.	Source of water	Turbidity.	Color.	Additional treatment.
High Springs	0.15	[illegible]	Deep well	0	0	.. ....
[illegible]	0.52	[illegible]	Deep wells	0	0	.
[illegible]	0.15	1.25	Deep well	0	0	.. ..
[illegible]	0.24	2.0	Lake	0	Slight	Filtration
[illegible]	0.60		Shallow well	0	0	... ...
[illegible]	0.05	0.4	Springs	0	Slight	... ...
[illegible]	0.19	1.6	Deep wells	0	0	. . . ...
[illegible]	0.19	1.6	Spring*	0	0	...
[illegible]	0.36	3.0	Lake	0	Slight	Filtration

*[illegible] from Magic Springs [illegible]

Sanitation in Flooded Districts

The sanitation of flooded districts is a very important matter in several states, for, although large floods such as occurred along the Ohio River in 1913 are of extremely rare occurrence, there are certain areas that are flooded at not infrequent intervals and even as often as every year by nearby streams reaching moderate high water stages or because of heavy rains within the areas and inadequate drainage. These floods though not usually endangering the safety of the persons living in the areas are a serious menace to their welfare because of the insanitary conditions produced. The precautions that should be taken to meet these conditions are well outlined by Harry F. Ferguson, acting chief sanitary engineer of the Illinois State Department of Public Health in Illinois Health News, the official monthly bulletin of the department, from which the matter following is taken.

While waters are at flood stage, wells may be dangerously polluted, especially since the contents of privy vaults are often washed out over the surface of the ground. Privies, because of the flood waters, often cannot be used and thus extremely insanitary conditions are liable to develop. Grounds and cellars become flooded with water which is generally badly polluted with human wastes and becomes malodorous. Many of the houses built in the areas subject to flooding do not have cellars and the first floors are often only a few inches above the surface of the ground and in such cases the floors and walls become soaked with the malodorous, polluted waters. The danger of disease at such times is probably increased because of a lowered vital resistance of the people caused by exposure and sometimes to a lack of proper food and nourishment. The chance for infection by contact is also often increased because of the prevailing insanitary conditions and the difficulty of practicing personal cleanliness under the disturbed conditions.

The principles and methods of sanitation in flooded areas are not different from those in regular use, but rather have to be applied in an emergency, wholesale manner and at the same time intensely. As the flood waters recede, the sanitary work should be carried on with the same vigor and proper attention should be given to making conditions normal and sanitary as soon as possible. The two most important items to be considered in the sanitation of flood areas are the water supply and the disposal of human wastes. If these two things are properly cared for, epidemics of disease can probably be avoided. Next in importance to the water supply and human waste disposal are those matters that might be considered as general sanitation such as the cleaning of flooded ground, cellars, and floors, and the collection and disposal of rubbish and wastes including dead animals.

If the sanitary work during and following floods is properly carried on, much sickness will be prevented. Though there is no tangible way of measuring such work, as in all health work that prevents disease, if the work is neglected, then the terrible effects of epidemics may be all too measurable. As a guide to proper sanitation in flooded districts, some of the more important items will be presented in some detail.

Water Supply.—If there is a public water supply, it may or may not be rendered unsafe by flood waters. If the supply is derived from drilled or driven wells and sometimes even dug wells properly constructed or is a river supply properly filtered and sterilized and the filter plant is not put out of commission, then the supply will probably continue in safe condition. If, however, the supply though normally pure is obtained from wells inadequately protected so that flood waters enter them, the water should be boiled during the flood and thereafter until investigations and analyses have shown the supply to again be in good condition. If the supply is an untreated surface water supply, then flood conditions will make little change in the quality for even under ordinary conditions surface water supplies cannot be considered safe. In addition to having the people boil the water from the public water supply, the officials in charge should install an emergency liquid chlorine or hypochlorite sterilizing apparatus for treating the water. Experience has shown that persons will not always take the precaution to boil drinking water, especially during disturbed flood conditions, and thus the water should be made as safe as possible before it is pumped into the mains.

Private wells of the drilled or driven type that are adequately protected at the top so that flood waters cannot enter them will probably continue to yield a safe water. Under exceptional conditions dug wells also properly constructed may continue to furnish a safe water, but should ordinarily be regarded with suspicion. Generally, the wells found in areas subject to flooding are of the shallow dug type and thus during floods become badly contaminated. Many of these wells even under normal conditions are not satisfactory sources of supply because they are not tight at the top and are located in close proximity to privies, cesspools, and other sources of pollution.

The best means of making the water from flooded wells safe in addition to boiling is to dose it with calcium hypochlorite, commonly known as chloride of lime. The capacity of a well should be ascertained and about 1 ounce of hypochlorite per 1,000 gal. of water added. The hypochlorite should first be dissolved in a small quantity of water and then thrown into the well. This may give to the water a slight taste, but such is not harmful and is even desirable, as the taste is a good index that the water has been properly sterilized. As long as the well continues flooded, applications of hypochlorite should be made at suitable intervals. Wells that have not been treated and used while flooded but are to be used when the water recedes should be treated with hypochlorite and then pumped out and cleaned and retreated with hypochlorite.

Cisterns may become flooded by surface water washing into them or by polluted water seeping into them through cracks above the normal flow line. If cisterns have been so contaminated or there is the least doubt as to the quality of the water in them, they should be treated with hypochlorite in a manner similiar to dug wells. If cisterns have become filled with highly polluted waste matter, then they should be emptied after being treated with hypochlorite and the walls should be thoroughly washed with a milk of lime solution prepared from freshly slaked lime.

During flood times, or until good water supply conditions have been re-established in areas from which flood waters have receded, community watering points can be established by providing barrels or tubs of water that have been treated with calcium hypochlorite. This would be similar to the methods followed in the army where portable canvas bags known as Lyster bags were erected at suitable points and filled with water and treated with hypochlorite.

Human Waste Disposal.—In an area provided with a suitable sewer system flood conditions may not cause any difficulty in the disposal of human wastes. In some low areas, however, sewer systems are at times placed out of commission because of flood waters. Such conditions generally result from improperly designed and constructed sewer systems and should be corrected. Where sewers are put out of use because of flood waters, sanitary privies for temporary use should be built. These preferably would be of the removable receptacle type and the waste matter should be carried to a suitable point for proper disposal. Where privies have become flooded or placed out of commission by flood waters suitable new sanitary privies should be constructed. If a large number of homes are affected then local officials should make arrangements for the construction at suitable places of temporary community privies.

In carrying on sanitary work in areas from which the flood waters have receded, privies should be immediately cleaned, repaired, and made fly-tight. If they cannot be suitably repaired, then new sanitary privies should be built. The important features to consider in privies is to see that they will not so pollute the soil as to endanger wells, that they will not permit access of flies to the waste material and that they can be maintained in a reasonably clean condition and odors kept at a minimum.

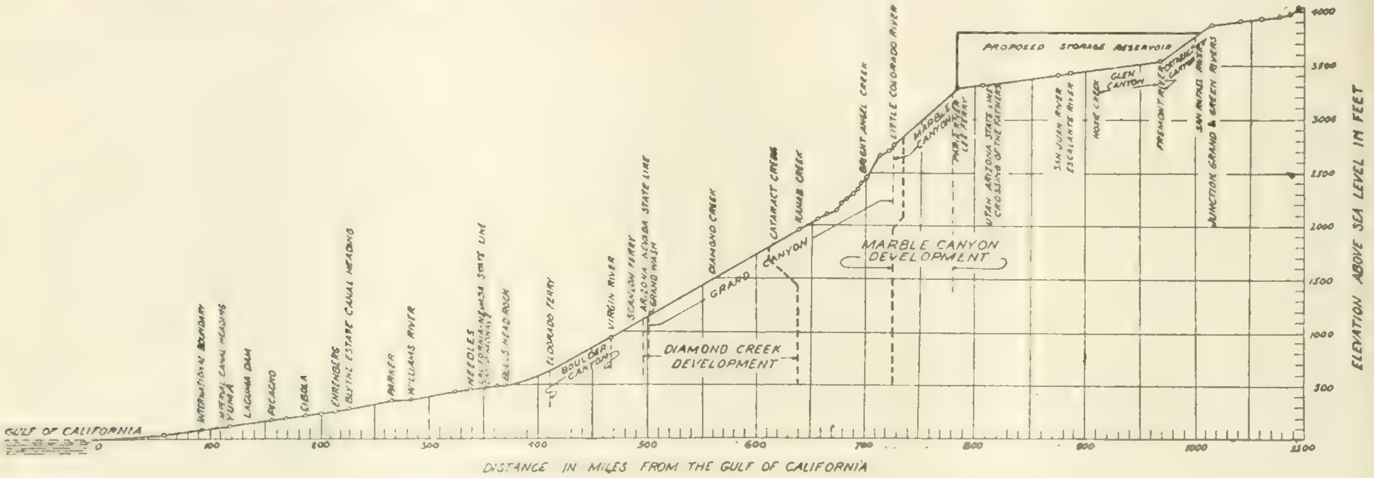
Deposits on Ground Surface.—Receding flood waters often leave a slimy malodorous deposit on the surface of the ground, together with miscellaneous rubbish, garbage, and dead animals such as chickens, cats, and dogs. As soon as possible the rubbish, garbage, and dead animals should be gathered up and properly disposed of, preferably by burying. If there are certain low areas that will not readily drain themselves, then suitable ditches should be constructed in order to eliminate such ponds and thus prevent the development of mosquitoes. Air and sunlight must be depended upon to improve the wet condition of the ground surface after the rubbish and other material has been collected. Quite often persons scatter lime indiscriminately about the premises, but such use of lime is a waste of time and money. As soon as the ground dries out under the influence of the sun and air, conditions are generally satisfactory. If, however, the waste deposit upon the premises is of such a character as to give off odors even when thoroughly dried, then the ground might well be sprinkled with a strong solution of milk of lime prepared from freshly slaked lime.

Cellars, Floors, Etc.—Cellars that will not drain out as soon as the flood waters recede should be pumped out and all cellar windows opened in order to admit as much air and sunlight as possible. The walls should be brushed and washed with a milk of lime solution or whitewash as this will not only brighten the walls and help dry them, but will serve as a deodorant and sterilizing agent. If the cellar floors are of cement, they should be thoroughly brushed, and scrubbed with lime solution. If the cellar floors are of earth, they should be raked as clean as possible and then sprinkled with powdered lime. The lime will help dry the floor and will serve as a deodorant.

Floors that have been flooded are generally left with a deposit of silt and slime and this should, of course, first be thoroughly removed by means of brooms and brushes. The floors and baseboards then should be thoroughly washed with soap and water. If odors prevail after washing the floors with soap and water, it would be advisable to wash them with a formalin solution. Walls, furniture, etc., that have been reached by the flood waters can also be washed to advantage with the formalin solution. Every effort should be made to admit as much air and sunlight to the rooms as possible.

General Sanitation and Personal Cleanliness.—Because human waste matter is generally scattered about by the flood waters it is very important that flies be reduced to a minimum. Flies should be excluded from the households as much as possible and prevented from gaining access to food. The streets, alleys, and stables should be kept clean of any manure that might serve as breeding places for flies. Garbage should be kept suitably covered until it can be properly disposed of, preferably by burial.

During flood conditions and during the rehabilitation following floods, individuals should make every effort to practice personal cleanliness the same as under normal conditions. This is often difficult during disturbance by floods or until suitable water supplies are readily available again and until proper means are provided for disposing of human wastes. However, the individual can do much, by making every effort to prevent the spread of objectionable waste matter, by endeavoring to practice personal cleanliness, and by avoiding contact with persons who apparently are disregarding sanitary measures. Though epidemics can be prevented by officials supervising water supplies and human waste disposal during and following flood conditions, the occasional cases of sickness can only be prevented by the individual co-operating in this work and making every effort to put his premises again in a sanitary condition.



Profile Showing Location of Proposed 200-Mile Storage Reservoir, Extending From Paria River to the Head of Cataract Canyon.

Large Colorado River Power Project

A large increase of available horsepower is involved in the ultimate plans of the Southern California Edison Co. in connection with its proposed Colorado River Project. An application for a preliminary permit to develop this energy from the waters of the Colorado River has recently been accepted by the Federal Power Commission, according to the Journal of Electricity, from which the following notes are taken.

The application contemplates the development of power on the Colorado River above the Bowlder Canyon Project, at Marble Canyon and Diamond Creek, but does not consider the possible power developments in the Grand Canyon and other sites along the National Park. Most of the available water power sites in California, capable of developing large amounts of hydroelectric energy have already been filed upon, and the Southern California Edison Co., to meet the future demands for power which have doubled during the last decade, turns its attention to the Colorado region as the next logical territory for future development.

Some of the possibilities of the Colorado River Project are outlined as follows:

1. Three thousand feet of waterfall will produce 4,350,000 HP.

2. Flood control will be absolute, reducing the water discharged to that volume which may be safely carried within the natural banks, levees being practically eliminated.

3. Provision will be made for irrigation of an additional 3,250,000 acres, of which 1,000,000 acres will be above the canyons and the balance below.

4. The storage basin will be over 200 miles in length, impounding more than 40,000,000 acre-feet of water.

5. Four hundred miles of the river will be made navigable.

6. The area which may be served with power includes three-quarters of the state of California, the entire states of Arizona, Nevada and Utah, more than one-half of Colorado and New Mexico and one-fifth of Idaho and Wyoming, with possibly large areas in northern Mexico.

7. Power may be used for the electrification of steam railroads, as well as for commercial, agriculture, mining and municipal uses in the entire district. The saving in fuel oil by the substitution of this hydroelectric power will amount to 90,000,000 bbl. per year, which is practically the present annual production of the entire state of California.

8. These savings in oil consumption will indefinitely extend the fuel life of our navy and merchant marine, which during the war were of necessity changed from coal to oil burning.

9. The Colorado River is the second largest river system of the country, having a drainage area of 250,000 square miles. Nature's arrangement of this stream for man's use is equaled by no other river in the world.

10. Ninety-three per cent of the run-off may be impounded above the storage dam, which will be 500 ft. in height.

Proposed Development of St. Lawrence River to Provide 5,000,000 H. P. and 30 Ft. Waterway

A proposed development of the St. Lawrence River involving the construction of five dams will provide a 30-ft. waterway and yield 5,000,000 HP. at an estimated cost of $1,300,000,000, according to a report recently submitted to the International Joint Commission on navigation and power development of the St. Lawrence River between Lake Ontario and Montreal by Hugh L. Cooper & Co. The following statements are extracted from the report:

The proposed development involves the construction of five dams with a generating station at each end of each dam (an arrangement essential to the handling of the great ice flows of the St. Lawrence), the provisions of a lock at each dam, and the deepening of the channel at the head of the Golops Rapids at the Long Sault and at Farran's Point. The dam which it would be most logical to construct first would be located near Croil Island, about 33 miles below Lake Ontario; the second would be installed near Massena Point, N. Y., about 15 miles farther downstream; the third would be about 44 miles farther along, near Cedars, Quebec; the fourth about 4½ miles below, near Cascades Point, Quebec, and the fifth about 20 miles downstream, near Cote St. Paul, Quebec. Approximately 40 ft. of head would be developed at each plant, the aggregate head being 196 ft. Locks would be provided at each dam to the total of six and would involve 3½ miles of canal.

The entire development, it is estimated, will cost approximately $1,300,000,000. The initial installation, 400,000 HP. of the Croil Island development, can be completed within five years. The remaining 600,000 HP. from this site can be installed in blocks of 50,000 HP. upon 20 months' notice as and when the demand for power requires it. Plants at the other four waterpower sites can be constructed by the electric service companies now operating in the vicinity of them or can be installed by others.

Development of plants Nos. 3 and 4 would provide 2,000,000 HP. for public consumption, compared with the 160,000 HP. now developed in the vicinity of these sites.

According to careful estimates, power can be made available to consumers from the proposed Croil Island development at $17 per horsepower-year.

The actual undertaking of this development cannot be expected to become an immediate reality, however, unless the governments of Canada and the United States, which have jurisdiction over boundary waterpower development, will recognize the relative benefits of the proposed plan, will waive duties on construction materials and restrictions on labor, will consent to free interchange of power, and will allow rates for power which will be commensurate with the unusual financial and engineering factors involved. Furthermore, each government must provide, operate and maintain all navigation facilities and adjust all damages resulting from changes in water elevations.

Collectively, the Great Lakes, Niagara River and the St. Lawrence River are the largest undeveloped resources of their kind in the world, yet the ratio of present power development on these boundary waters to the ultimate possible is negligible. At present only about 850,000 HP. is developed at Niagara Falls, whereas at least 2,305,000 HP. can be developed without marring the beauty of the Falls. This additional available power plus the 5,000,000 HP. which can be developed as proposed on the St. Lawrence would provide a total additional 6,625,000 HP. or 66 per cent of the total waterpower horsepower installed in the United States. Owing to the more constant flow of the Niagara and St. Lawrence Rivers, this power could be developed at 25 per cent higher load factor than the average in the United States and thus produce the equivalent of 82 per cent of the energy now generated by water power in this country.

Considering this enormous amount of available hydroelectric energy, increased importance should be attached to the following advantages of water-power development:

(a) Every 35 hydro horsepower which is developed releases one laboring man's efforts for one year for more profitable engagement. This means that 190,000 men would be made available by the proposed development for other business, say, agriculture and industrial.

(b) Seventy times more labor is required to produce a given quantity of steam-electric power than to give the same quantity of hydro-electric power. This takes into consideration labor required in the mining of coal used as well as generating-plant personnel.

(c) Every hydro horsepower saves on the average more than 10 tons of coal per annum, or 66,250,000 tons in this case.

(d) Hydro-electric energy saves every consumer $35 per horsepower-year on the average, or $231,875,000 based on the proposed developments. This alone would justify an expenditure of $1,932,000,000 if capitalized at 12 per cent, the average return on industry before the war, or more than the proposed canalization and power development of the St. Lawrence River would cost.

(e) Water power reduces freight rates on general commodities through saving of coal and releasing railroad property and equipment for more productive uses. More specifically, 36,000 freight cars and 600 locomotives, valued at $141,000,000, would be released by this development, to say nothing of other railway property used solely in connection with this coal equipment and amounting to an additional $530,400,000.

Aside from the foregoing advantages would be the increased speed of traffic in the St. Lawrence River and the reduced rate per ton, the development of new industries, the reduction of coal exports to Canada and hence its greater availability at a lower ton cost in the United States and the increased business on the Erie Canal which would result from new industries.

Results of Lime Softening of Water Supplies.—In their recent report on a new water supply for Kansas City, Mo., Fuller & McClintock, Consulting Engineers, state that several important American cities are purposely using large doses of lime for softening their water supplies. St. Louis, New Orleans and Grand Rapids are cited as being the best examples of lime softening on a large scale. The operating results of these plants are given as follows in the report:

	St. Louis.	New Orleans.	Grand Rapids.
Period considered	1918-19	1918	1919-20
Population, 1920	773,000	387,408	137,634
Water treated daily, mil. gals.	104	32.5	14.1
Average turbidity of raw	1,500	500	17
Alkalinity raw p. p. m.	130	100	191
Effluent p. p. m.	43	39	72
Incrustants, raw p. p. m.	53	25	49
Effluent p. p. m.	58	28	55
Total hardness, raw p. p. m.	183	125	241
Effluent p. p. m.	101	67	135
Hardness removed p. p. m.	82	58	106
Hardness removed, per cent	45	46	44
Lime used, grains per gallon	5.56	4.61	5.60
Hardness removed by one grain per gallon	14.7	12.6	19.
Lime cost, per ton	$ 8.75	$11.30	$12.01
Lime cost, per mil. gals.	$ 3.82	$ 3.75	$ 4.60
Lime cost, per part hardness removed	4.66c	6.46c	4.35c
Quality of lime, per cent CaO	84.3		88.7

Personnel and Scope of Work at Various Waterworks Laboratories.—In their recent report on the water supply of Kansas City, Mo., Fuller & McClintock, consulting engineers, gave the following table showing the personnel and scope of work at various waterworks laboratories:

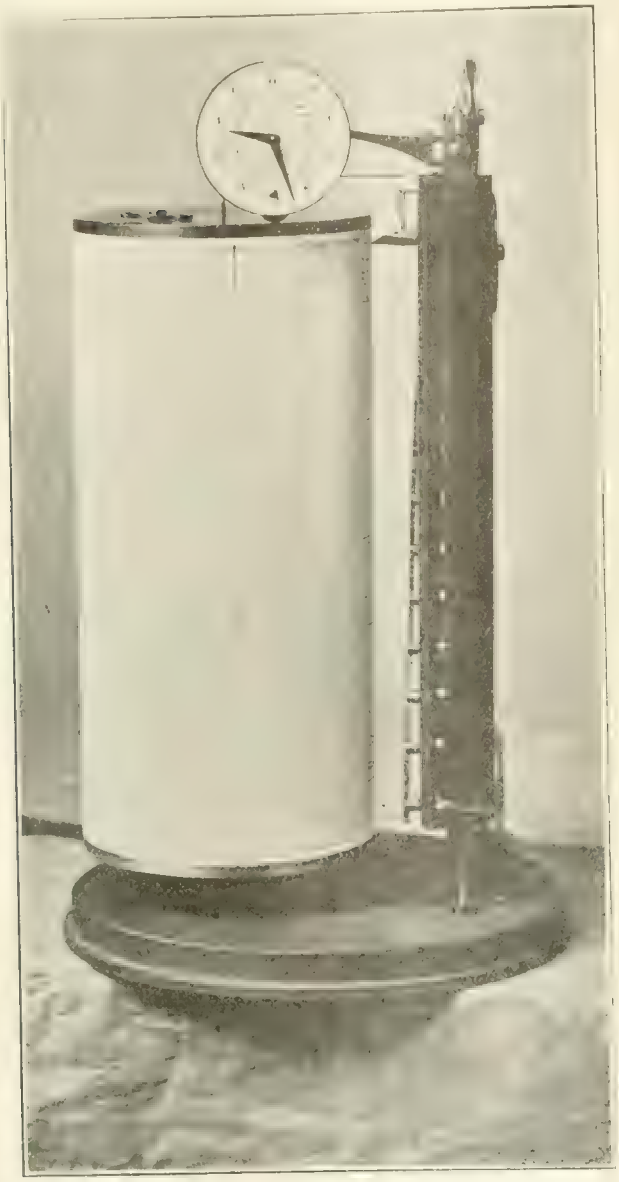
City.	Population, 1910, thousands.	Daily consumption, m. g.	Chief chemist.	Asst. chemist.	Asst. bacter.	Laboratory helpers.	Kind of work.
Indianapolis, Ind.	...	24.3	1	2	0	2	ABCDEG
Louisville, Ky.	..	26.0	1	1	1	0	ABCEF
New Orleans, La.	.	30.0	1	2	1	0	ABCEG
Grand Rapids, Mich.	113	12.4	1	3	0	0	ABCEFG
Minneapolis, Minn.	301	30.0	1	0	1	1	ABCDG
St. Louis, Mo.	687	98.0	1	2	2	4	ABCDEG
Albany, N. Y.	100	20.0	1	2	0	1	ABCEFG
Cleveland, Ohio	560	96.0	1	0	1	2	ABEFG
Columbus, Ohio	182	20.0	1	3	0	0	ABCEFG
Cincinnati, Ohio	363	50.0	1	1	0	1	ABCEFG
Kansas City, Mo.	248	50.0	1	0	1	0	ABG

A—Bacteriological.
B—Turbidity, color, odor, alkalinity.
C—Sanitary, chemical.
D—Mineral.
E—Coagulants.
F—Microscopical-plankton.
G—Coal and special.

New Water Level Recorder and Flow Meter

A new instrument for recording water levels and measuring flow which has recently been put on the market is in reality two instruments combined. The recorder is a complete water level recorder in itself designed for small conduits, weirs or other devices where the range of heads do not exceed 2 ft. The flow meter is a separte integrating attachment that may be put on at any time.

The purpose of the flow meter is to save the labor of computing the volume of flow from the record of water levels. It may be set to record the total volume of water passing the instrument in acre-feet, gallons or any other unit desired. It is operated by an adjustable spiral cam that may be set for any weir, headgate, canal, flume or ditch that is rated, or for any device or condition where the height of water is an index of the flow. A carriage carrying a pen is moved up and down by a float resting on the water. The pen marks a line on the record paper fastened around a drum that is turned by an 8-day clock inside the drum. The combination of these two motions makes a record of the rise and fall of water. The record of heights may be made either to actual size or to one-half actual size by a simple adjustment of the line to the float.



Stevens Water Level Recorder and Flow Meter.

The flow meter operates somewhat on the principle of a planimeter. A friction wheel resting on top of the drum is turned by it. The angle this wheel makes with the direction of motion of the drum is made to vary adjustably with the [illegible] water. A suitable gear train causes hands to indicate on a graduated dial the number of revolutions made by this friction wheel. By a simple adjustment of a spiral cam and the use of an integral multiplier the revolutions thus indicated are readily converted into acre-feet, gallons, cubic meters or any other unit of volume flowing in any rated conduit or passing any weir, headgate or other measuring device.

A check is always had on the record of the flow meter through the simultaneous records of water levels. Thus it is claimed that the convenience of the water meter is secured with the additional advantage of being able to check the results and determine rates of flow if desired.

The instrument is manufactured and distributed by Leupold Voelpel & Co., Portland. Ore.

Engineers for I. C. Commission and for Assistant Secretary of War.—The American Engineering Council of the Federated American Engineering Societies has sent to President Harding a communication asking that an engineer be appointed Assistant Secretary of War. Another communication requested Mr. Harding to name an engineer for the vacancy on the Interstate Commerce Commission. Both communications were authorized by vote of the Executive Board of the Council, of which Herbert Hoover is president.

Personals

G. R. Hall, Oconto Wis., has been elected president of the Wisconsin State Drainage Association. Other officers are Jerry Donohue of Sheboygan, vice president; Anton Brost of Babcock, treasurer; Professor E. R. Jones of the agricultural college, secretary, and O. R. Zeasman, also of that branch of the university, assistant secretary.

Chester G. Wigley of Maplewood, N. J., formerly engineer of the New Jersey State Board of Health, was re-elected president of the New Jersey Sewage Works Association at its annual convention Feb. 19. Other officers elected are S. Fisher Miller of South Orange and Morford C. Smith of Newton, vice presidents, and Myron E. Fuller of Summit, secretary-treasurer.

Dwight P. Robinson & Co., Incorporated, engineers and constructors, New York, has recently opened branch offices in Montreal in the Dominion Express Bldg. Alexander C. Barker, vice-president, is in charge of the office. The company is a consolidation of Westinghouse, Church, Kerr & Co., Inc., and Dwight P. Robinson & Co., Inc., and has done extensive construction and engineering work in Canada for the Canadian Pacific Ry., Canadian Salt Co., Canadian Crocker-Wheeler Co., Dominion Government, Aetna Explosives Co., Grand Trunk Ry. and others.

Herman C. Wolf has been appointed assistant chief engineer of the Public Service Commission of Maryland. Mr. Wolf, who will be the electrical engineer for the commission, has been in Mary land for some time as one of the staff of the Chicago firm of engineers which is surveying the Maryland State departments and which collected data for the installation of the merit system. He is a graduate of the University of Illinois and was at one time assistant engineer of the Illinois Public Utility Commission. He was with the Engineering Corps of the army during the war, serving 18 months overseas.

The firm name of the E. A. James Co., Limited, consulting engineers, Toronto, Ont., has been changed to "James, Proctor & Redfern, Limited." The names of E. M. Proctor and W. B. Redfern are well known to those who have had dealings with The E. A. James Co. Mr. Proctor has been with the company as managing director since September, 1916, and continues his work as vice-president and managing director. W. B. Redfern, who previous to going overseas, was the town engineer of Steelton, joined the company in May, 1919. During the past year Mr. Redfern has acted as secretary-treasurer for the company and will continue in that office. The change in the name gives recognition to the services of Messrs. Proctor and Redfern. The business will continue as formerly, an organization of consulting municipal engineers.

Industrial Notes

The firm name of the John F. Byers Machine Co., Ravenna, O., has been officially changed to the Byers Machine Co.

Fred E. Schwalb, who has had charge of special engineering for the Weller Manufacturing Co., Chicago, has been appointed chief engineer for that company.

The National Steel Fabric Co., Pittsburgh, Pa., has opened a sales office in the Mutual Bldg., Kansas City, Mo., in charge of H. H. Robinson.

The Chippewa Pump Co., Chippewa Falls, Wis., manufacturer of deep well plunger pumps, has moved its Chicago office to 20 East Ontario St. J. C. Huffman is district manager.

The Lakewood Engineering Co., Cleveland, O., announces the appointment of Kelly Powell, Limited, 403 McArthur Bldg., Winnipeg, Canada, as agents for the Province of Manitoba, Saskatchewan, Alberta, and Western Ontario, for the sale of Lakewood paving, construction and industrial equipment.

Blaw-Knox Co., Pittsburgh, Pa., will exhibit its new "Dreadnaught" type clam shell bucket at the National Railway Appliances Association convention in Chicago, March 14 to 17. Working models of all types of Blaw buckets for every digging and rehandling need will be arranged for inspection. A new type of portable steel watchman's or flagman's shanty will also be shown.

The Equitable Equipment Co. has just completed its organization for the purpose of handling railroad and contractors' equipment and second-hand machinery and equipment. The new company is taking over the equipment, rail and machinery business of A. Marx & Sons, Southern Scrap Material Co. and the Ship Supply Co. The new firm will be under the direct management of Mr. Cleveland, who has been the manager of the New Orleans branch of the General Equipment Co and will have offices at 411 Whitney-Central Bldg., New Orleans, La.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Is the Missouri "House" Immoral or Merely Ignorant?

State legislators are probably above the average voter in native intelligence and certainly in education. Hence the laws that they pass are superior to those that would be secured by popular vote. How very little the average voter knows about political economy may therefore be judged by the little that state legislators know, as evidenced by the bills that they pass every year, also by the bills that they refuse to pass.

The lower house of the Missouri Legislature has just passed a bill reducing railway passenger fares to 2.5 ct. a mile. By a vote of 102 to 23 these legislators seek to reduce the 3.6 ct. fare recently established by the State Public Service Commission. Consider, for a moment, the significance of this 6 to 1 vote by the Missouri legislators. It shows, for one thing, that they are either immoral or exceedingly ignorant. If they believe themselves capable of justly deciding a rate case without weighing all the evidence they are very ignorant. If they fail to take evidence and lower the rates merely to please the people, they are immoral. They are equally immoral if they pass such a bill, knowing it to be sure of veto at the hands of the governor.

We regard the 102 members of the Missouri Legislature as being ignorant rather than immoral. Our schools and newspapers foster the idea that any intelligent American is competent to pass upon any question of political economics. It is not strange that under such teaching most of us come to have a wholly inadequate conception of the extent of knowledge needed to judge as to the fairness of a given railway rate, for example. Are we not intelligent Americans trained to politics from the cradle? And is railway regulation not a political matter?

The American people have yet to learn that very few political problems can be correctly solved by any one, who is not a specialist. Indeed, they have yet to learn that political questions should be approached as problems susceptible of scientific solution, rather than as matters for wordy debate. As yet, neither school teachers nor newspaper editors are attempting to show voters what their limitations are when it comes to solving political problems.

The Decreased Output of Railway Employes Following the Abolition of Piece Work

Shortly after the federal government took over the operation of the railways in 1917, the piece rate system of paying shop employes was abandoned. Immediately the output of the workers fell off. Judging from data recently presented to the Railroad Labor Board, the average decrease in output per man-hour was about 30 per cent, as a result of adopting an hourly payment plan in place of the piece rate plan. For example, the efficiency of the freight car repairers of the Chicago & North Western fell off 36 per cent. That of the car repairers of the eastern lines of the Pennsylvania Ry. decreased 22 per cent. Similar falling off occurred in the shops of the Union Pacific, the New York Central, the Chicago, Burlington & Quincy, the Norfolk & Western, the Louisville & Nashville and other railways, indicating an average drop in shop labor efficiency of about 30 per cent for all the railways, following abandonment of piece rate payment.

Reversing the percentage base, this is equivalent to an increase of nearly 50 per cent in labor efficiency following the introduction of piece rate payment as compared with payment by the hour. This result confirms the general experience of manufacturers as to the percentage of increased hourly output that occurs when some system of payment in proportion to performance is adopted.

There are several important inferences to be drawn from these data and from the action of the government in discontinuing piece rate payment. First, the willingness of a representative government to adopt an uneconomic system if it is popular with workmen. Second, the desire of the workmen to substitute an uneconomic system if their daily wages are not immediately reduced by the substitution.

Bear in mind that the only essential change in bringing about this great decrease in hourly output of railway shop workers was the change in the method of payment. The same foremen and superintendents remained in charge after Uncle Sam became the general manager as were in charge before. But Uncle Sam introduced a new policy of management, and in doing so violated the most important single law of management, namely, the law of payment in proportion to performance. The result was inevitable.

Those who believe in government ownership and operation of railways and public utilities will do well to ponder the results of our government operation of railways during the war. It was not the existence of a condition of warfare that caused the great slump in railway shop workers' efficiency, for that did not occur until the hourly pay system was substituted for the piece rate system.

Eventually—possibly a century hence—the average worker will be so well educated economically and ethically that he will work as industriously under one system of payment as another. At present, however, there is no possibility of securing a fair day's work from the average worker except under some system of reward for personal efficiency or punishment for failure to perform a specified minimum of work.

It is this condition that leads us to question the ultimate economic success of any extensive plan for "democratizing industry." If the workers are able to decide what the managerial policies shall be, what is to prevent their doing just what was done in the railway shops of this country when the government took over the control? The government then catered to the desires of the workers, and with results that were disastrous to their efficiency. Are not most men truly but "children of a larger growth," governed more often by their immediate desires than by the results of broad experience?

Should Courts Select Expert Witnesses?

The suggestion has often been made that expert witnesses should be hired by the courts, in order to avoid the partisanship in their testimony. Some degree of partisanship, it must be admitted, is likely to exist when expert witnesses are employed by both parties in a legal controversy. But such partisanship is not entirely undesirable. Certainly there are forms of partisanship that are helpful in arriving at truth. For example, whenever a radically new scientific theory is presented, a debate begins and soon becomes extremely partisan in character. On the one side are those who resist the innovation as if it were religious heresy. On the other side are the radicals who see little or no truth in pre-existing theories. Between the extremes the truth may subsequently be found to exist, but during a scientific controversy neither side is inclined to yield a jot.

In expert testimony before courts, there is usually involved a considerable amount of theory, and a divergence of opinion over the theory. For this reason, if for no other, it seems desirable not to permit any court to select all the expert witnesses.

George I. Rockwood presented a paper in 1899 before the American Society of Mechanical Engineers on the value of water powers. In a discussion of this paper William Kent said:

> The idea that a court expert can be substituted for ex-parte experts is all wrong, for who is to insure that he has that scope of knowledge, that breadth of judgment, and that freedom from pre-conception that he can see all sides of the case? The whole truth is more likely to be brought out by the conflict of the witnesses on opposing sides.

With this statement we are in accord, but we believe that a court should either be composed of technical men where a technical case is under trial, or that the court should employ technical advisers. It is customary in England for judges to employ such advisers who sit through the trial and weigh the testimony of the expert witnesses. Then the court ordinarily relies upon the conclusions reached by its technical adviser. Perhaps this is the most practical solution of the problem at the present time, for the public is still too ill-informed about technical problems to realize that a technical court is essential where just decisions are to be reached as to technical evidence.

Most of our state public service commissions, which are judicial in their nature, do, in a measure, rely upon the judgment of their engineers, and thus avoid many errors that would otherwise occur. The main objection to this practice lies in the fact that the engineers of such a commission are often partisan witnesses themselves. Being employed by the public and in association with attorneys that represent the public, it is very difficult for the engineers of a commission to free themselves entirely from bias. Their theories often conflict with those of the engineers employed by public utility companies. Where such conflict occurs they would be superhuman were they not to advise the commission that the theories of the company's engineers are wrong.

The editor has been the engineer of a public service commission, and is acquainted with many commission engineers. He knows that engineers in such positions strive to be unbiased, but that they do not always escape being partisan. He believes that every public service commission should have as a member at least one engineer, so that the commission will not be entirely dependent upon the advice of its own engineers who so frequently testify in opposition to the engineers employed by public utility companies. Where it is impracticable to secure the appointment of an engineer as a member of a commission, it may be possible to bring about the appointment of an engineer as technical adviser of the commission.

Engineering societies should appoint committees to study both the law and the methods of procedure governing the trial of railway and public utility rate cases. Then concerted and unceasing effort should be made to effect desirable changes. Stagnation in railway and public utility development had been growing progressively worse prior to the world war. The war served to make a bad condition worse. Unless some body of men undertakes to show the public how to change conditions under which railways and other utilities operate, there will be no satisfactory development in this great field even after the present business depression ends. What body of men is more competent to advise the public on this subject than the professional engineers of America?

A Court Decision That Pre-War Price Levels Are Not Applicable in Present Appraisals

In nearly every rate case before a court or commission the contention is made that prewar prices should be used in valuing property built prior to the war. Courts, however, are refusing to recognize this contention. For example, in a recent decision by the U. S. District Court of the Southern District of New York (P. U. R. 1920 F, p. 483) we read:

> Several reasons lead me to believe that present price levels are not merely transitory, though I recognize the danger of any prophecy. Whatever their precise cause it is universally conceded to be due to the great war, and by that I mean, of course, not to the prosecution of hostilities, but to the economic exhaustion and inflation of the circulating medium which these involved. In general, it is a safe inference to suppose that Europe will not be able to resume its ante-bellum production for a time measured rather by years than by months, and that the recovery of a sound financial condition will take longer. We, in this country, are not only influenced by conditions in Europe, but we are subject to our own local inflation and disorganization of industry, from which no one can know when we shall recover. The question is a practical one and comes, I think, down to this: the plaintiff is faced with a condition which permits it to receive much less than the return which the statute contemplated and which the Constitution is thought to insure it. So far as human foresight can see, that condition, though probably not permanent—certainly in its present exaggerated form—is bound to exist over a period of some years, at least in such things as coal, oil and labor, which are the plaintiff's chief costs. There is then the certainty of a continued loss for an indefinite, but substantial time, due to causes which were not in existence and could not possibly have been apprehended fourteen years ago when the rate was fixed. Does this prospect justify the court in abandoning the inertia which it properly feels when the complaint is based upon temporary variations? Is it fair to continue to impose a rate which has clearly ceased to correspond with the underlying presuppositions upon which it was based? I think that the prospect does justify the court and that the rate has become unfair, at least until the conditions change.
>
> I have just said that the present range of prices seems to me applicable not only to the cost of production but to the valuation of the "rate base," i. e., the permanent means of production, and this necessarily involves a decision upon the vexed question as

to the values upon which the company is to be permitted to earn its profit. Costs of production involve those items which the company must pay before it begins to see any profit whatever; its economic motive for embarking in, and maintaining, the enterprise depends altogether upon the return which it can get out of the property which it has bought and erected into an industrial unit. Hence it is the profit, and strictly speaking this alone, which matters with the stockholders. It must be owned that much of the discussion shows either a timidity or an inability to grasp any principle in dealing with the "rate base." With deference it appears to me to be merely an abandonment of any att[illegible] intelligibly with the question to say that cost of reproduction and the original cost are each elements to be considered. That statement can mean nothing whatever unless it is accompanied by a constitutive rule which will establish some standard by which these may be used. It would be understandable to say that the two estimates should be averaged, but such a rule could obviously command no support, because it would correspond to no relevant considerations of policy. Merely to leave the question with a caution that several elements are to be considered is to abandon any effort to solve it.

The recurrent appeal to a just rate and a fair value assumes that the effort is to insure such a profit as would induce the venture originally and that the public will keep its faith so implicitly given. That, I think, involves a tacit comparison of the profit possible under the rate with profits available elsewhere, i. e., under those competitive enterprises which offer an alternative investment. The implication is that the original adventurer would compare future rates, varying as they would with the going profit, and would find them enough, but no more than enough, to induce him to choose this investment. By insuring such a return, it is assumed that the supply of capital will be secured necessary to the public service. As the profits in the supposed alternative investment will themselves vary, so it is assumed to be a condition of the investors' bargain that their profit shall measurably follow the general rates. It is, of course, not relevant here to discuss these presuppositions, since they have now the support of authoritative law.

Certain risks in ordinary competitive enterprises can be reasonably anticipated and business practice includes them in an amortization account. New processes and machines are constantly appearing which make the old obsolete; ordinary wear and tear makes necessary replacements. The return, to make these good, is commonly carried in a separate account by all prudent business men and does not come out of the rate. It is true that individual misfortunes cannot be foretold, and these a given company must bear just as any single competitive venture would have to bear them. Among these, however, is not a general rise in prices, which affecting all alike at least after a time, enables each to raise his price not only because of his costs in labor and in materials, but to obtain a proportionate increase in his profit, based upon the increased value of his plant and machinery. All competing producers, who give the same service, must keep invested an increased number of dollars in capital to do so. The risk of the depreciated dollar is not one which industry in general will bear; it is indeed no risk at all.

Moreover, a profit, based upon the enhanced value of the capital, adds nothing in truth at all to the company's wealth. Though its capital be measured in more dollars and so, too, its profit, that profit is still paid in the fallen dollar and has no greater buying power than it had before. The increased valuation of the capital will, for the years of the depreciated dollar, leave the company exactly as it was; it will merely prevent its being compelled to share its putative fair profit with its customers, which by hypothesis it should not be asked to do. The company gains nothing, the customers lose nothing.

Indeed all this is so much in the primer of economics that it is inconceivable it should be misapprehended as to working capital, for instance, and the contrary view has crept in, I think, only when one thinks of the more permanent kinds of capital, and instinctively assumes that the rate will apply after that capital has resumed its former prices, if it ever does. There is in short a tacit assumption that the valuation must last as long as the permanent capital. There is no warrant for that assumption, because precisely the same reasons which compel the "rate base" to be raised after a rise in price, compel it to be reduced after a fall. There is natural enough reluctance to a continuous reappraisal of plants and properly so. It must, of course, appear that the variation in prices is not transitory, and the period of probation, before a company is allowed relief, is precisely to insure against that possibility. The chance of loss during that period such companies must endure, and there is an inevitable "lag" in readjustments in each direction. But once it appears that the new price levels are not transitory, it is no answer to the company's complaint to say that at some future time prices may fall. When that time comes, if it does, the property must again be revalued, but meanwhile they are entitled to some protection, and, since these have become questions for the courts, to the protection of the courts.

The rule of the present reproduction cost, which is a ncessary consequence of the foregoing argument, appears to me to have been either expressly or implicitly recognized in all the cases in which the Supreme Court has passed on these matters. Willcox vs. Consolidated Gas Co., 212 U. S. 19, 41, 53 L. ed. 382, 29 Sup. Ct. Rep. 192; Des Moines Gas Co. vs. Des Moines, 238 U. S. 153, P. U. R. 1915D, 577, 59 L. ed. 1244, 35 Sup. Ct. Rep. 811; Knoxville vs. Knoxville Water Co., 212 U. S. 1, 10, 53 L. ed. 371, 29 Sup. Ct. Rep. 148; The Minnesota Rate Cases, 230 U. S. 352, 434, 454, 455, 57 L. ed. 1511, 48 L. R. A. (N. S.) 1151, 33 Sup. Ct. Rep. 729, Ann. Cas. 1916A, 18; San Diego Land & Town Co. vs. National City, 174 U. S. 739, 757, 43 L. ed. 1154, 19 Sup. Ct. Rep. 804; San Diego Land & Town Co. vs. Jaspar, 189 U. S. 439, 442, 47 L. ed. 892, 23 Sup. Ct. Rep. 571; Darnell vs. Edwards, 244 U. S. 564, 568, P. U. R. 1917F, 64, 61 L. ed. 1317, 37 Sup. Ct. Rep. 701. It is true that its application has not distinctly arisen since the recent rise in prices, but it is not possible that it should have general application and yet not cover this, its most glaring illustration.

A Country Without Railways

The situation existing in China today, which is being brought to the attention of the American people by the Committe for the Chinese Famine Fund, is one that has many serious aspects outside of the necessity for charity. The facts are that China in her five northern provinces is suffering from the worst famine in her history and perhaps in all recorded history. In an area of some 100,000 square miles, 45,000,000 are threatened with famine; 15,000,000 are literally starving and the reports tell us that deaths from starvation and disease are occuring at a rate of 10,000 a day. The reason for all this misery is that continuous drought for 18 months has caused the failure of three successive crops. China is not a poor country; it has much wealth, although of a potential character, and its agricultural possibilities are not small. We are told, for example, that food in abundance can be purchased in Manchuria. The chief difficulty in China is that it lacks transportation and has not reached that stage of economic agricultural development that goes with the building of railway lines and highways. Each agricultural community presumably is in a measure an economic entity in itself. Such a community is not developed to the point where it can raise a surplus nor would it be worth while for it to raise such a surplus, because it could not dispose of it. China proper, exclusive of Mongolia and Tibet, has an area of 1,532,420 square miles and a population of over 300,000,000 as compared with an area of 2,973,890 in the United States and a population of 105,000,000. To serve its large area and enormous population China has but 6,000 miles of railway lines. It is plain enough that the need for assistance in the present emergency is most urgent, but it is equally plain that to avoid a recurrence of such disastrous conditions as exist at present, China needs new railways and lots of them. It is certainly to be hoped that the eyes of the rest of the world will be opened to that fact, to the end that the many projects and proposals for extended railway development to make available China's great potential wealth may become actualities with less delay through international politics, diplomatic discussion and jealousy.—Editorial in Railway Age.

Good Scholarship in College and Eminence in Engineering.—A close correspondence between good scholarship in college and eminence in engineering is shown in an investigation made under the auspices of the American Association of Collegiate Registrars by Prof. Raymond Walters of Lehigh University, who presents a report in the current issue of "School and Society." It was found that of 392 distinguished engineers graduated at 75 technical schools, colleges and universities, 182 or 46.4 per cent, stood in the highest fifth of their classes scholastically upon graduation, 109 or 27.8 per cent stood in the second highest fifth, 72 or 18.3 per cent in the middle fifth, 14 or 3.6 per cent in the next to lowest fifth, and 15 or 3.8 per cent in the lowest fifth. Figures for a group of 189 alumni of five eastern engineering schools were somewhat different in the upper classes, the second highest scholastic fifth having the largest percentage. In all groupings of the eminent engineers there were less than 4 per cent in each of the two lowest scholastic fifths. Of 730 names on the Registrar's Association list of distinguished engineers, practically 80 per cent were found to be collegiate graduates, 16 per cent men of secondary school education and practical training, and less than 5 per cent men who started in college but did not finish. The arbitrary basis of eminence in this study of a professional group was taken to be the holding of office, membership in important committees and service as representatives of the four "founder" engineering societies, civil, mechanical, electrical, and mining and metallurgy, for five years, 1915-1919.

Selecting the Foundation Types

By CHARLES EVAN FOWLER,
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The selection of the type of foundation for a particular location or structure, must always depend more largely upon the judgment of the engineer than for any other class of engineering construction, and extensive practical experience is the only safe basis for making a correct decision. However, by careful consideration of fundamentals, and an analysis of the various methods, certain limits may be fixed for each type of pier foundation, and the chance for error in making a decision reduced to a minimum.

The fundamentals to be considered are the character of the foundations as regards permanency; the type of superstructure and pier shafts to be supported; the forces acting upon the spans, piers, and foundations; the character of the material through which each foundation is to be constructed and upon which it is to land; the chances for the scouring out of the bottom around the piers; the depth to which the foundations must go; and the probable cost as compared to the possible expenditure allowable.

When the foundations are to be wholly temporary or even relatively so, then they should be of an economical type of construction, and of shallow depth or rest upon piles. When they are to be of a semi-permanent character to last at least a few decades, they may be founded on piles, or by means of a caisson of some type to reach to a moderate depth, which must be safely below scour; but when they are to be truly permanent foundations, such as to surely outlast one or perhaps several superstructures, then it may safely be assumed that some type of caissons must be used to reach to a great enough depth to be safely below scour, and to reach a material that will carry the resultant loads and pressures upon the base with a satisfactory safety margin. There may occur cases where it is necessary to go deeper than is demanded by ordinary requirements, in order to build the foundation courses below any possible depth to which the channel may in future be dredged, or perhaps below some other proposed foundations.

The character of the material of which the bottom is composed is a very vital factor in arriving at a decision, as to whether to use piles or caissons, and also as to whether the caissons are to be of the open dredged type or of the pneumatic type.

The test boring should be made in sufficient number, to a great enough depth, and close enough together, to make it possible to plot them and construct a geological or boring section. This will usually disclose the fact that conditions had not been fully disclosed by even the most careful study of the individual borings, and that the depths for foundations must be varied from the preliminary ones contemplated. The final depths will more frequently be increased than otherwise, due to the fact that the stratum first considered is underlaid by one not so reliable, or that a uniform thick bed of better material is developed at a greater depth, but within easy reach.

Where the depth of the channel is not to be materially deepened by future dredging and where there will be no chance for scour, as in a tidal channel or cul-de-sac branch of a harbor, then pile foundations may be considered, in case the material is compact enough to give proper bearing capacity for the piles, or where it is underlaid by harder material to which the piles can be driven.

When the material is very soft or even moderately so, and the foundation must be constructed to carry heavy loads, then it is advisable to use a caisson to reach a reasonably hard stratum that will support the loads either directly, or when aided by a truly conservative allowance for skin frictions. There can seldom be any allowance made for buoyancy, except for a pier on piles in really wet materials, because in most cases if water can get under the pier base, it is a sure indication that a permanent foundation must be carried to a greater depth. No allowance as supporting power can be made for earth displacement, nor for lateral earth pressure, as that is provided for in the values recommended by the writer for a skin friction supporting power, the allowable amount per square foot increasing with the penetration. The allowance in vertical bearing capacity per square foot may be increased as the depth of penetration below the surface or stream bed increases, due to the confined condition of the material, and as determined by the formula on Page 275 of Vol. I of "Engineering and Building Foundations," P = 0.68 a + 0.014 ah, in which a is a constant varying for each class of material, and h is the depth below the surface or bed of the stream. This is derived from the Antwerp quay wall experiments. The values of a are the usual safe values for each class of material at a penetration h of 23 ft. beneath the surface or stream bed, and are given below in the first column in tons per square foot. The values for compact material at the surface are those given in the second column and the maximum recommended for any condition or depth greater than 23 ft. is a value equal to 1.4 a, as given in the last column.

	(a)	(h-o)	(1.4a)
1—Alluvium or silt (firm)	1.5	1.0	2.1
2—Sand and clay, moist	1.5	1.0	2.1
3—Fine compact sand	4.5	3.1	6.3
4—Sand and gravel	5.0	3.4	7.0
5—Sand and clay, dry	5.0	3.4	7.0
6—Hard clay	5.0	3.4	7.0
7—Hard pan	8.5	5.5	11.9

When wholly reliable borings disclose soft material such as No. 1 and No. 2, then piles or caissons must be considered for any loads except very light ones; but firm material consisting of sand, sand and gravel, or dry sand and clay, such as No. 3, No. 4, or No. 5 not subject to scour, provide a first-class foundation bed for loads within the limits given; and where it is necessary to go to considerable depth to be safe against scour or to reach a greater bearing capacity, then material such as No. 3, may be considered as comparatively easy to penetrate with a pneumatic caisson, by the use of sand pumps or ejectors; as would also be true for softer materials such as No. 1 and No. 2. However, at even comparatively high wages it would quite surely prove cheaper to sink caissons through such material as No. 3 by open dredging, as would also surely be the case for materials such as No. 4, No. 5, and No. 6, or in sand and loose gravel, dry sand and clay, and hard clay. Caissons designed for sinking by open dredging through clay or gravel that may change to harder material like hard pan or cemented gravel, should be arranged for putting on air shafts and locks, if it becomes necessary or advisable. This provision is also desirable when it is likely that sunken logs or other debris may be encountered.

The bearing capacity of confined material is also frequently determined by the use of the Rankine formula, which is for a factor of two:

$$P = \frac{1}{2}\left(w\,h\tan^4\sqrt{45^\circ - \frac{1}{2}a}\right)$$

P = pressure in pounds per square foot.
w = weight per cubic foot of material.
h = penetration of pier in feet.
a = angle of repose of material.

When the foundation is under water, then the values of "w" and "a" must be those for submerged material, which are approximately as follows:

	W.	A.
Fine compact sand	60 lbs.	26° 34′
Sandy clay	65 lbs.	18° 26′
Sand and gravel	65 lbs.	26° 34′
Gravel, ordinary	60 lbs.	26° 34′
Clay, ordinary	80 lbs.	15° 57′

The diagram herewith gives a graphic comparison of the two formulas, and shows that for ordinary depths the values obtained from the Rankine formula are very low, and less than commonly used or than those recommended by the writer. When the depths are very shallow the Rankine values become illogical, as shown by the following comparison:

Depth.	Antwerp.	Rankine.
2	3.5T	0.2T
10	4.1T	1.0T
23	5.0T	2.4T

When the foundation is not under water then the values of "w" and "a" are approximately as follows:

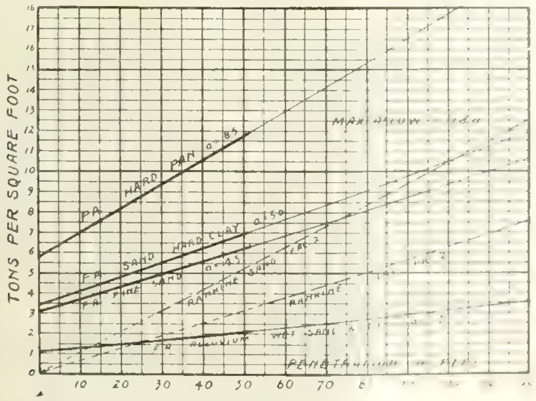
	W.	A.
Fine compact sand	90	34° 0′
Sandy clay	100	32° 0′
Sand and gravel	100	26° 0′
Gravel	110	42° 0′
Clay, damp	110	29° 0′

The diagram herewith makes possible a quick determination of the proper unit load to allow upon any class of material in a foundation bed, except one of rock. The depth given is for the penetration in feet below the bed of the channel, or where the bed will be when fully dredged or scoured out, and not for the depth below the water surface. The allowable load, in tons of 2,000 lb. per square foot, is given at the left. The heavy portion of the lines marked F. A. are for the Fowler-Antwerp formula up to the maximum limit of 1.4 a; while the lines are extended to give values for great depths of penetration; but values greater than 1.4 a are to be used only when very careful and extensive tests have developed all of the elastic conditions, and a greater reliability of the soil has been actually proven. The lines marked "Rankine" are shown, merely to afford a basis for comparison with the others, and for use only when for some reason it is deemed desirable to adopt an ultra-conservative bearing value; the values need in no case be taken below those for the "F. A." formula near the surface or stream bed; or for sand at 3.0 tons per square foot, and for dry clay at 3.5 tons per square foot. Nor should any greater values be used than 1.4 a, it being borne in mind that in any case an allowance for skin friction is in effect an increase in the bearing capacity of the entire foundation bed or stream bottom.

The values used for bearing on the foundation beds of 24 important structures are given in the following table. The value denominated "Test" is the load in short tons per square foot which produced a compression of the soil much greater than was deemed advisable to allow, and which tests were frequently made in such detail as to make possible the plotting of the elastic curve; also it is interesting to note that the factor of safety adopted in most cases was greater than two; but in three cases where there was no safety factor used, there was settlement or cracking of the masonry, thus indicating the necessity for using a really proper safety margin.

FOUNDATION PRESSURES FOR IMPORTANT STRUCTURES.

No.	Material.	Location.	Test.	Used.	Factor.
1.	Sand, fine	(Corthell)	10 ex.	4.5	Avg. load
2.	Sand and gravel	(Corthell)	33 ex.	5.1	Avg. load
3.	Sand and clay	(Corthell)	10 ex.	4.9	Avg. load
4.	Hard clay	(Corthell)	16 ex.	5.08	Avg. load
5.	Blue clay	N. Y. Capitol	5.0	2.0	2.5
6.	Yellow clay	Congress. Library	13.5	2.5	5.4
7.	Hard clay	N. P. Bismarck Br.	15.0	3.0	5.0
8.	Gravel, coarse	Cinti. Susp. Br.	....	3.5	
9.	Sand over rock	Brooklyn Bridge	....	5.5	
10.	Clay (London)	Cannon St. Br.	....	6.5	Settle
11.	Clay (London)	Charing Cross Br.	....	9.0	Settle
12.	Clay (London)	Tower Bridge	6.5	4.0	1.6
13.	Clay, solid	Memphis Br. (old)	9.5	(9.0)	Crack
14.	Sand, fine	Wash. Mon'm't	9.0	2.7	3.3
15.	Clay, hard	Tacoma 600' Stk.	12.0	4.4	2.4
16.	Clay, hard	Seattle Locks	12.0	4.0	3.0
17.	Clay, ordinary	Audt. Tower	18.0	2.0	9.0
18.	Sand, ordinary	World's Fair	2.25	1.25	1.8
19.	Sand, compact	St. Paul B. N. Y.	....	3.2	2.0
20.	Sand. com., wet	Spreckel's, S. F.	....	3.0	2.0
21.	Clay, red	Willards, Wash.	....	4.0	2.0
22.	Gravel, ordinary	Eiffel Tower	....	3.0	.
23.	Clay, solid	Memphis Br. (new)	9.5	9.0	1.0
24	Sand, ordinary	Tay Bridge	7.8	3.9	2.0



Load on Foundation Beds.

The first four examples are the averages taken from Corthell's "Allowable Pressure on Deep Foundations," and they are quite fully discussed on pages 230 and 231 of Vol. I of the writer's "Engineering and Building Foundations." Cases from No. 5 to No. 14 inclusive are also given in detail in Chapter XI of the same volume, but it may be noted here that the very large pressures commonly stated for the Washington monument can not be verified, and it is quite certain that under the highest winds it does not exceed the 9.0 tons given in the first column of the table. This became apparent when the writer compared it with the calculated excentric pressure on the 600 ft. Tacoma smelter stack for a 125-mile wind velocity, the data of which will be given in Vol. II of Engineering and Building Foundations. The test load given is the same as for the Seattle Lock, inasmuch as the hard clay was exactly similar, and would usually be classed as "hard-pan." The apparent lack in nearly all of the examples is first, a too indefinite recording as to the class and condition of the material; second, not enough detail in the records of the test loads, especially as to the effects and settlements, which would make certain that the factor of safety was realized; and third, the effects after applying, with the actual construction, what is termed a safe load.

Dredged Caisson, 20x80x54 Ft.

There never will be need nor any possibility for very great refinement for foundations, as to the allowable unit load to be used on each class of material, and it is to be deplored that any attempt is being made towards ultra-refinement in this regard, which can only result in leading the novice or young engineer to overlook the fact that the important thing is to use careful and mature judgment in determining the condition of the material, or in foreseeing a bad condition that may be possible; and also that there must be ample margin for contingencies and ultimate safety. The following classification will assist in forming a correct judgment as to the safe bearing values of soils.

Alluvium or Silt.—There are two classes of alluvium or silt; (1) practically pure earth in a very finely divided state and having mixed with it a very small percentage of fine sand; and (2) the same class of finely divided earth, with a very large percentage of sand, and which is really class (1) of fine sand, as given in the second division, or under sand.

The conditions of alluvium are, (1) dry alluvium or only slightly moist, and which will carry safely a load of 1.0 ton per square foot at the surface; and (2) wet alluvium, which will carry a very temporary foundation by floating, and which must have piles driven in it or else cassions sunk through it for a permanent foundation.

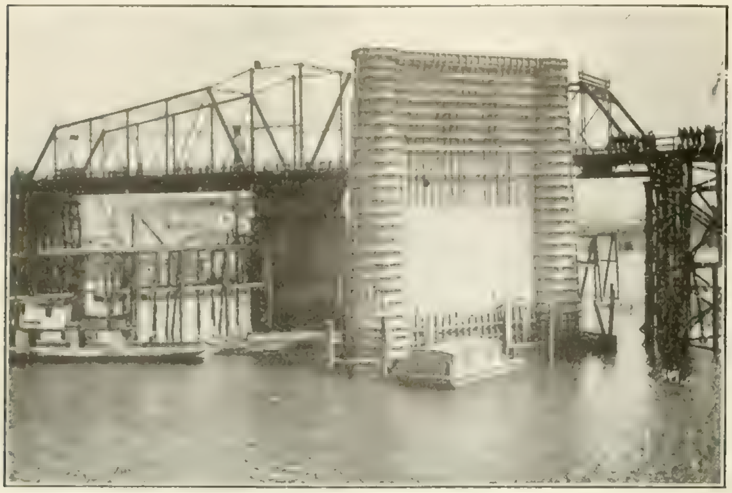
Sand.—There are three general classes of sand; (1) fine soft river or pit sand with a considerable percentage of silt; (2) fine sharp quartz sand nearly or quite clean; (3) coarse sharp quartz sand nearly or quite clean.

The conditions of sand are, (1) dry sand, which in reality is always at least damp or slightly moist; (2) moist or slightly wet sand, which is, however, firm and compact; (3) wet sand, which is water bearing and often called "quick sand" by mistake, but which is really only a "sand high ball," from which the water can be readily drained by proper methods, and (4) true quick sand, which often exercises a distinct downward suction, and which cannot by practical methods be freed from water.

Gravel.—There are five general classes of gravel; (1) fine gravel, with a large percentage of sand; (2) medium gravel, with a maximum of 2-in. pebbles, much of small pebbles, and a very considerable percentage of sand; (3) medium coarse gravel similar to above, but with very little sand; (4) gravel in which there is a large percentage of boulders; and (5) cemented gravel.

The condition of fine gravel, with a large percentage of sand, may approximate that of sand, but will less seldom be found to be water bearing. The coarser grades of gravel are usually firm and afford a fine foundation bed.

Cemented gravel is a fine foundation bed and is of two classes or grades; one which is only loosely cemented and easily broken up; and true cemented gravel which approximates concrete in solidity and hardness, and which usually requires blasting to break it up thoroughly.



Fowler Reinforced Concrete Pier.

Clay.—There are five general classes of clay: (1) yellow clay, of yellowish color and containing a large percentage of earth; (2) red clay, of marked red color and containing a large percentage of earth; (3) gray clay, or ordinary compact pure clay; (4) blue clay, which is of bluish tinge, but is a compact and very hard pure clay; and (5) gray or blue clay, which is so very compact and hard that it is termed "hardpan."

The condition of the first four classes is that they are usually moist or damp, but are often so wet as to be unstable and apt to slide. When dry, or only moist or damp, clays are first class as a foundation bed, and are considered better than dry sand or loose gravel, but when wet they are to be looked on with suspicion, unless a sure method can be devised for draining them, or of draining the water away. Hard-pan is always a good foundation bed, and remains solid under water, but may have a tendency to slide if water can or does follow through seams or softer underlying strata, and if such water can not be drained away in a sure manner.

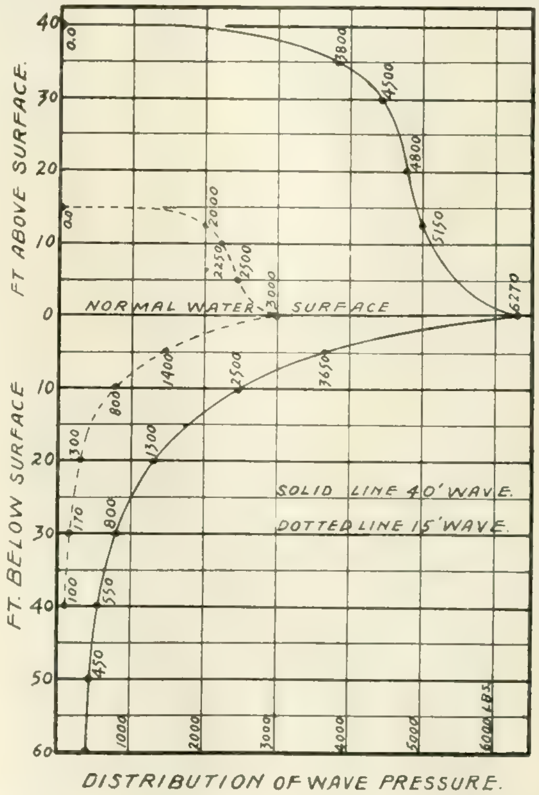
The determination as to the character of the material in a foundation bed, and below the surface, or below the bed of a stream, must largely depend upon careful borings and this has been fully covered in Chapter XII of Vol. I of "Engineering and Building Foundations." However, it is advisable to caution against over confidence in wash borings, unless they have been made in sufficient number to prove their reliability upon plotting the entire section. Even then if they have not been carried to a depth of at least 20 or 30 ft. below the probable depth of the foundations, a bed of boulders found at nearly the same depth in all borings may be mistaken for a stratum of rock, as has been done in the past; or else lenses or pockets of clay may be mistaken for a real stratum of clay. Where difficulty is had in attempting to make core borings through a soft bed overlying hard strata, then casings may be sunk to the solid material by the wash boring process, and then core borings carried on from that depth, and thus have the more reliable core borings into the material which will probably be chosen for the foundation bed.

The final determination as to the depth to which foundations must go, or to which caissons must be sunk, will depend in a large degree upon the actual transverse forces acting against the superstructure and the pier shafts, and it is surprising to find that many important structures have and are being built, with no careful investigations of the transverse forces, and only too frequently with no allowance for such resulting eccentric pressures, thus nullifying the apparent factors of safety.

Where structures are on a curve, centrifugal force may be a vital factor in determining the eccentric loading of a pier or caisson bed. Wind force is always a serious factor in designing foundations, and due to the fact that the very conservative value of 30 lb. per square foot for maximum wind pressure is in almost universal use in superstructure design, the fact has often been overlooked that winds of a velocity of from 100 miles per hour up to 132 miles per hour as recorded near Astoria, Ore., in January, 1921, or up to 140 miles per hour as recorded near New Orleans in September, 1915, can act upon structures near the coasts. Thus it will be found in many cases that the 56-lb. pressure used in designing the Forth and Tay bridges is little enough for safety, or that greater pressures up to 75 lb. per square foot, or more, must be taken into account; and preferably as a requirement for a special design for the entire structure, including the foundations.

The usual currents of a stream are not swift enough in most cases to be serious factors in the design of foundations, especially if a cross section has been adopted for the pier shafts giving the least resistance possible to the stream flow. However, some tidal channels and streams during flood have a velocity for the water that does become a vital factor, ind is frequently from 12 to 15 miles per hour. The pressure of ice, and particularly of ice james, become serious foundation problems when the designer has a soft or relatively soft bottom in which to place foundations; and not solid rock as was the case for the notable Victoria bridge piers built by Robert Stephenson in 1858, for the bridge across the St. Lawrence River at Montreal, and described on Page 418 of Vol. I of "Engineering and Building Foundations," and which have withstood the enormous ice pressures for over 60 years.

The results of the terrific force and destruction from waves has been demonstrated in the Galveston storms of 1900 and 1915, and the Corpus Christi storm in 1919. The latter storm caused a storm tide ranging from 12 to 16 ft. above the highest ordinary high tide, and the waves were from 10 to 12 ft. in height and of great destructiveness. The maximum blow from such waves of translation must reach nearly to 3,000 lb. per square foot, and for any important structure that must be built to withstand such forces, a careful study must be made of the resultant forces, and preferably the structure be made of special design for opposing them.



Wave Pressure at Various Depths and Heights.

The distribution of wave pressure above and below the normal water surface can safely be taken from the data given by Prof. Luiggi for a wave having a surface pressure of 6,270 lb.; or at 13 ft. below the surface, 2,015 lb.; at 19.5 ft. below, 1,335 lb., and at 49 ft. below of 450 lb. The reduction above the water surface being, for 13 ft. above, 4,930 lb.; for 32.25 ft. above, 4,260 lb.; and presumably, or at least safely, reducing to zero about 40 ft. above.

This curve is shown graphically on the diagram in the solid lines for a 40 ft. wave, and this should be used for ocean lighthouses or other structures exposed to the full force of the open ocean waves, as given herein for Peterhead; while the values from the dotted curves for a 15 ft. wave should be used for structures in a fully exposed position, such as or similar to Mustang Island or the open waterfront at Corpus Christi. Similar curves may be drawn for lesser waves, if a lesser maximum can be definitely fixed. The curve below the water surface conforms closely to the shape of the curve of current distribution for a combination of ordinary and storm currents, as determined by the writer's investigations before stated, and one quite fully corroborates the other. The curve of pressures for waves breaking would not conform to the curve shown for pressures above the water surface, but the latter would give safe results in any case. The force and effect of waves of translation has not been fully studied, but it is certain that they transmit twice the force of oscillatory waves, and it is certain that this force is accentuated by the driving force of the wind and storm tide.

The various factors entering into the design of foundations, having been reviewed at length and in some detail, each method of constructing foundations, and each type of foundation will be discussed in the March 23 issue of Engineering and Contracting, to make plain the limitations and possibilities of each, both as to ease of construction, permanence, and economy.

Railway Mileage of the World

The following figures recently issued by the Bureau of Railway Economics show the railway mileage of the world as of 1917. Owing to causes well understood, these figures are substantially the same to date:

Continent and country.	Miles of railway
America:	
Alaska	655
Argentina	22,310
Barbados	109
Bolivia	1,502
Brazil	16,557
British Guiana	104
Colombia	708
Canada	30,788
Chile	5,014
Costa Rica	546
Cuba	2,331
Dominican Republic	400
Dutch Guiana	37
Ecuador	652
Guatemala	613
Haiti	140
Hawaii	88
Honduras	150
Jamaica	196
Martinique	139
Mexico	15,840
Newfoundland	874
Nicaragua	200
Panama	298
Paraguay	291
Peru	1,728
Porto Rico	340
Salvador	199
Trinidad	108
United States	259,555
Uruguay	1,639
Venezuela	634
Total—America	364,745
Asia:	
Arabia (incl. Cyprus)	61
Asia Minor (incl. Syria)	3,337
British East Indies	35,277
Ceylon	671
China	6,838
Cochin China, Cambodia, Anam Tonkin	1,490
Japan (incl. Chosen)	8,855
Malay States (Borneo, Celebes, etc.)	857
Malacca	57
Dutch East Indies	1,773
Persia	34
Pondicherry	59
Portuguese Indies	51
Philippines	691
Russia (Asiatic)	9,886
Siam	976
Total—Asia	70,913
Africa:	
Algeria and Tunis	4,220
Belgian Congo	1,028
British East Africa	2,355
French Africa	2,449
German Africa	2,595
Italian Africa	106
Morocco	777
Portuguese Africa	1,183
Union of South Africa	11,237
Total—Africa	29,921
Australia:	
New South Wales	4,133
New Zealand	2,973
Northern Territory	145
Queensland	4,867
South Australia	2,168
Tasmania	701
Victoria	3,871
Western Australia	3,665
Total Australia	22,523
Europe:	
Austria-Hungary (incl. Bosnia and Herzegovina)	28,704
Belgium	5,477
Bulgaria	1,509
Denmark	2,642
Finland	2,429
France	31,958
Great Britain	23,696
Germany	40,381
Greece	1,012
Italy	11,337
Luxemburg	326
Malta, Jersey, Man.	68
Montenegro	12
Netherlands	2,113
Norway	1,975
Portugal	1,854
Roumania	2,388
Russia (European)	36,219
Serbia	977
Spain	9,538
Sweden	9,290
Switzerland	3,293
Turkey (European)	1,131
Total—Europe	218,628
Recapitulation:	
America	364,745
Asia	70,913
Africa	29,921
Australia	22,523
Europe	218,628
Grand total	706,730

Tie Renewals in Relation to Average Life

That there is a general law governing the rate of renewals in all groups of railroad ties, no matter what kind of wood is used in the ties, where they are placed, or whether they are untreated or treated with preservatives, is the indication of records kept by the Forest Products Laboratory, Madison, Wis. These records show a wide variation in the lives of various groups of ties but a remarkable similarity between the percentages of ties that needed replacement at proportionate intervals in the lives of any two groups.

The comparisons are based on 43 groups, including 42,000 ties of many species, some untreated and some treated. For any of these groups, the percentage of renewals in relation to the percentage of average life is fairly represented by the curve shown in Fig. 1.

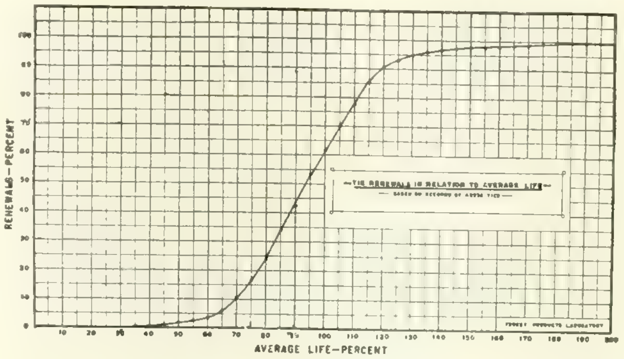


Fig. 1—Tie Renewals in Relation to Average Life, Based on Records of 42,936 Ties.

This curve answers several valuable purposes. It can be used in estimating the average life of a group of ties long before all the ties in the group have been removed—also to show the number of replacements that will be necessary during a given year.

As an example assume that out of a group of 1,000 ties, 200, or 20 per cent, have been removed at the end of four years. From the curve it will be seen that 20 per cent of a group is usually removed at about 77 per cent of the average life. The average life of this group, then, will be 5.2 years. Further computation shows that the number of replacements to be expected during the fifth year is about 350, the sixth year 300, the seventh 100, and that at the end of nine years practically all the ties in the group will have been reemoved.

Courses in Transportation for Railway Engineers

From an article in the Professional Engineer, we learn that the Great Northern Ry. has recently inaugurated courses in transportation for the benefit of professional engineers and others in the employ of the company, as a result of suggestions made by the Great Northern Section of the American Association of Engineers.

An Educational Bureau has been formed composed of eight of the general officers of the railway, such as the general auditor, superintendent of transportation, superintendent of motive power, etc., who will have general oversight of the courses offered.

Instruction will be in form of typewritten lesson sheets furnished by the Great Northern Ry., which will be distributed by the bureau to engineers over the entire line. A critique will be held each week, at which time the author of the paper of instruction will be present to discuss the subject matter and answer questions. Men in outlying portions of the line will write in requesting solution of any question they may have to ask and written replies will be made to these.

The entire course will cover every phase of the railroad business. The first course offered will be a general course in railway matters, but as soon as possible more specific subjects will be offered. All students who wish to attend the weekly critiques may, and critiques and lectures may later be held at various division points of the Great Northern. Some textbooks may be used for assignment reading. There are about 300 engineers on the Great Northern R. R. for whom the present general course is designed.

Equitable Railroad Contracts*

By H. R. SAFFORD

President, American Railway Engineering Association.

When your President invited me to speak on the subject of equitable railroad contracts, I manifested some degree of reluctance, not because I hesitated to assist him, but because I felt doubtful of my ability to suggest anything of value or constructive character, upon a subject of such familiarity to you.

I had an inclination to say to him that if anyone wanted to be enlightened upon the subject of equitable railroad contracts all they had to do was to look over any modern contract and he would find unquestioned perfection, and an overflowing measure of equity—the product of the unassailable character of learned minds—out attorney friends have always said so, in fact, even publicly admitted such.

We were led to believe these contracts represented the moral law—as firm as the legislation of the Medes and Persians—and that anyone who disputed that opinion assumed violent risks.

However, as I look back upon my experience, I recall that some of your profession have dared question those opinions; fearless combatants have disputed that estimate of perfection based on well-established traditions, and, after some legal jousting, have unhorsed some of our gallant defenders. Then we learned that the word "equity" looked differently to different people, and it has become more and more evident that the two parties to a contract should try to look at the contract from the same viewpoint as far as their relative commercial positions would permit. The nearer that viewpoint coincides, the easier will be made the construction and execution of such contracts.

Putting Equity Into Contracts.—I took occasion to look up the meaning of the word "equitable." An accepted dictionary defines it as "Possessing or Exhibiting Equity." It seemed to me that that definition was particularly appropriate to the application of the subject in hand. The only thing to be added was the phrase "for both Parties"; so it should be defined as "Possessing and Exhibiting Equity for Both Parties."

Such should be the starting point in developing an "Equitable Railroad Contract" and be the base for the five essential things to a contract:

1st. The intent.
2nd. The obligation.
3rd. The rights.
4th. The liabilities.
5th. The specifications.

Equities exist in all five of these features.

Many of the difficulties, which have grown out of the execution of contracts, have been from the failure to express intent clearly. Ambiguity is dangerous and leads to misunderstanding which may be prevented by a little more care in expression. Well expressed intent makes easier the declaration of subsequent stipulations.

The intent being clearly expressed, the next important thing is the declaration of the obligations of both parties. and herein lies probably the essential feature—because these are purposes of the transaction and relationship.

A contract should be modeled upon the assumption that it is a mutual and voluntary pact undertaken by parties both of whom approach the relationship for a definite purpose; one, for the purpose of gaining profit from service for which there is an insured or guaranteed remuneration; the other, for the purpose of creating a structure or condition hoping to obtain a definite financial return. These purposes should be borne in mind in analyzing the contractual obligations.

This relationship is voluntarily sought and that fact alone demands that the obligation should be respected and not transferred to each other because of unexpected conditions not the direct result of the other's disability. To feel or plan otherwise is to play the hypocrite or impostor, and generally trouble will ensue, and that trouble punishes both parties: one by needless expense, the other by loss of standing, and such loss is often irreparable.

The obligation upon the employer is definite, to show the contractor the way he should go in the performance of his service—to promptly supply funds and pay for that service and to give the contractor every reasonable facility and encouragement to develop the greatest degree of efficiency. One cannot emphasize this obligation too strongly, for it is to his interest to do so if for none other than a selfish reason in advancing the completion of his finished structure and thus obtain the earliest possible period of productivity.

A Partnership of Efficiency.—The local managers or engineers of both parties should feel reciprocal interest in co-operating in a partnership of efficiency.

Efficient co-operation is a good thing, and both sides can often make contributions in the form of suggestions relating to improving the methods of construction without sacrificing advantage or prerogative as expressed in the formal agreement.

The obligations upon the contractor are definite also. They are: first, to plan the work in a thorough and practical manner; second, to do the work as directed by the employer; and third, to assume the usual risks incidental to a voluntary action and for which he is being compensated at agreed figures, which are assumed to cover service insurance if such be required.

The contractor is not an agent according to certain well and legally established definitions of the word and to the extent that the employer is responsible for his actions without considerable restrictions, but he is in a sense an "Agent of Service," and, as outlined heretofore, has the obligation of an agent in the practical sense.

He is an agent in the sense that he should feel a personal interest in the welfare of his principal and the same desire that any loyal employe should feel, for, after all, he is an employe of a temporary character.

In meeting the obligations the contractor sometimes needs help. The extent to which his principal will help him depends upon the contractor's attitude in the features heretofore defined.

Emergencies Which May Arise.—The most perfectly written agreement will not cover all possible conditions and emergencies which may arise, and sometimes I think we are too much inclined to anticipate too much, thinking that the extent to which we can foresee possibilities establishes a high rating of intelligence, and that tendency has furnished both the engineers and our legal friends much opportunity for fine legal phrases and many "wherases." We perhaps overdo the anticipating business, and forget the importance of being a little more clear in the expression of intent and purposes, but, on the other hand, the development of the modern contract is a great deal like the development of rules for operating a railroad, both for handling trains and maintaining the property, in that every rule is the epitaph of a tragedy.

Originally in early operation of railways a dozen rules were sufficient for safety and expedition. But as speeds began to increase and traffic to grow in magnitude, risks became greater, and, as the tax on mental operations began to increase, the weakness of the human mind grew more pronounced and errors and inefficiency multiplied; the disregard of others' rights was magnified and the results were so troublesome that new and better rules became necessary in order that responsibility might be fixed and discipline applied.

The history of railroad contracts has been quite analogous in many ways, and the so-called errors and weaknesses magnified because of the commercial aspects as apart from the matter of running of trains—this due to the ambition and greed of which both parties were guilty.

The tendency to lay out a wonderful plan of contract strategy has perhaps developed wonderful imaginative power, but the danger lies in playing this too strong, and creating suggestions for sharp practice.

I do not mean that we can radically remodel and quickly change existing basic principles and phraseology, but I do say, let us keep in mind more fully than ever before the desire to express the spirit of the contract, and the letter of it will be more easily and briefly written and interpreted.

Strictly fair dealing on both sides will automatically introduce simplicity and minimize anticipated difficulties.

Both Parties Have Rights.—Another important feature is the rights. Both parties have rights and they should be clearly indicated and thoroughly consistent with the obligations, for the obligation of one party oftentimes is the right of the other. There are other rights, however, that should be recognized. Legal rights are established in a pretty thorough manner. Rights in equity are less easily indicated and perhaps are difficult to outline and define. The partition between law and equity sometimes is very thin and in the exercise of the discretionary power of the prin [illegible] is uncertainty as to which should be respected, the quality of service rendered by a contractor is a large factor.

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*From an address presented Jan. 27 before the Second National Conference of the Associated General Contractors of America.

Legal rights of either should not be surrendered generally to equity without good grounds, but may be surrendered in part or in whole if there is evidence of a fair disposition to place a high value upon the obligation and intent.

It must not be forgotten that in most contracts of magnitude the execution is in the hands of authorized corporate officers whose first duty is to their company, and they have no alternative but first to protect their owners' interest and have no right to yield to personal and sympathetic influences.

The right of the employer to be protected against damages from inadequacy and inefficiency on the part of the contractor, is unassailable, and conversely the right of the contractor to be protected against the tyranny and destructiveness of an unfair employer is well established and recognized.

We have all known of instances of violation of such rights, but I believe they are becoming more and more infrequent, due to the growing tendency on the part of employers to deal with contractors of established financial standing and reputation for reliability.

One right which has been the cause of more difference of opinion than possibly any other is the right of suspension of work generally exercised by the employer. I have always felt that there was a strong similarity between suspension and the cancellation of an order in commercial life, the only difference being the magnitude of the effect and the relative ease with which the seller of his product can find other customers.

In industrial life the price of the salable article is built up of direct cost, indirect cost, carrying risks and profit. The risks embody period suspension possibilities and presumably you, in making your prices, embody corresponding items therein.

You are justified in doing so, and when done this should be given consideration and in the determination of the allowable amount to cover idle period, I have always felt that for some proportion of the period there should be no allowance upon the theory that the contractor should assume part of this risk. I speak of both partial and complete suspension in this thought, and this principle is common to both cases.

A railroad must suffer the loss which comes from the sudden decline in traffic and the manufacturer also suffers the same chance. There is one difference sometimes when the contractor acquires special equipment upon the expectation of using it for the work in question. For such a condition a contractor is entitled to some consideration, and when these possible conditions arise, it becomes apparent that equities must, and they do, govern. Neither party can expect the other to protect him to his full power; both must take a fair amount of risk. That amount is not always foreseen and cannot be estimated in advance. Its calculation depends upon the spirit in which the agreement is entered into and the sincerity of purpose behind the action of each.

Time and Equity Essence of Contracts.—So these things come down, after all, to a situation in which equities are the foundation. We often find in the modern contract the phrase, "Time is the essence of this agreement." I would hope some day to see that phrase expanded to read, "Time and equity are the essence of the contract with due regard to sound legal princples." Those are the three articles which should be sealed in the cornerstone of the true contract.

We come to the last of the five terms—"Specifications." I have hardly known how to approach this feature without getting into unlimited detail and feel constrained to deal with essentials only.

Thoroughness, clearness and practicability appear to me to be the three essentials. Here is the employer's duty, for he designs—the contractor builds.

Thoroughness is necessary to enable the contractor to calculate his bid; clearness, to minimize misunderstanding; practicability to insure lowest cost and expedition.

We often hear contractors justly complain about the deficiency in these things, and such complaints should have the closest attention. Engineers may easily err in any one of these three things.

Inexperience may be a factor; carelessness sometimes causes this. In other cases disregard of the element of cost and economy may be a cause.

In the natural development of our profession, I am more and more impressed with the difficulties which exist in correlating text book and experience of the builder. In times past I have seen too much of failure, to listen to the viewpoint of the builder—to hold aloof from him in forcing a strict compliance with specifications without seeking advice and help from the builder, especially when he is fortified with good experience. I want to see in the future a closer feeling of joint responsibility to the extent of encouraging the builder to give of his knowledge and experience, to listen to suggestions and advice with due regard of course to the danger of yielding too much, but we should remember that no one agency can know it all.

The Force-Account Contract.—I have not spoken of one very important matter, viz., the application of the so-called "Force-Account" contract.

I have heard a prominent contractor say he saw in the future only one type of contractor and one type of contract. In asking him to define his dream a little more clearly, he said, "A contractor 100 per cent strength, integrity and efficiency, and a force-account contract?"

I pray for the former, a 100 per cent employer, but I have no such optimism about the latter.

I thoroughly approve of the force-account contract, where certain conditions require it, but I cannot conceive of anything more objectionable than to eliminate the competitive advantage of unit prices. The world would never have developed without some of them. The mental and moral uplift in keen competitive bidding is real. It should never be removed, but that does not mean that the other type is better. The one thing that will remove the prejudice against the force-account contract is for you contractors to devise some way to convince the employer of low costs. Devise some way to get the same degree of efficiency where profit is assured as where it is not assured. Remember how advantageous it is for you to sublet on unit-cost bidding.

Good Contractors an Asset.—I believe today the cases of abuse of either legal or equitable rights is growing less. That should be so. A contractor's best asset is his reputation for fair dealing. One of the best assets the railroad business has is a good list of contractors who can be depended upon to help the railroad.

Unfair and destructive treatment of a contractor is bad business policy. It is apt to destroy a real asset or cost the railroad higher unit prices.

The liabilities of the contractor should be fully protected by either well established credit or by bond. This the railroad has the right to expect. There should be no hesitation on the part of the contractor to so protect.

The liabilities of the railroad are definite. They are of a character not subject to the same method of safeguarding as is required of a contractor, but are just as specific and just as sacred.

The Cement Gun in Railway Work

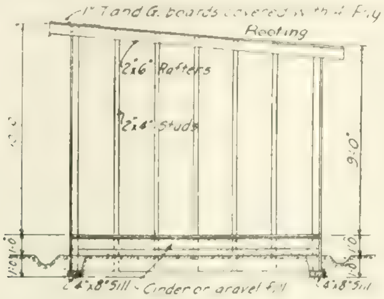
As an appendix to the report of the Committee on Roadway of the American Railway Engineering Association, presented at the March convention, some uses of the cement gun in railroad work are noted as follows:

In 1914 the New York Central R. R. used a cement gun in its Spuyten Duyvil Cut on the main line, about 10 miles north of Grand Central Terminal, New York City. This is probably the most extensive work of this sort yet attempted. The cut was 500 ft. long with sides 80 and 50 ft. high, respectively. The Third Rail System furnished the power for operating the air compressors. The first operation was to remove the small loose stones and dirt from the crevices by air, before using the cement, and it was thought advisable in some places to use anchor bolts 1 in. in diameter in order to insure holding up some of the larger rock, the mixture of one to three parts cement and sand was then used. This work was done in 1914 and 1915, was inspected by a member of the committee in June, 1920, and found to continue satisfactorily.

In 1914 the Lehigh & New England R. R. at Lansford, Pa., used the cement gun in the roof of a tunnel, part of which was lined with brick, the balance not lined. Some of the brick had fallen out; others had become loose; the rock in the unlined portion frequently fell to the track, but after treatment with cement gun the condition was corrected. There are several streams of water emptying on to the track from the roof of this tunnel, which the manufacturers of the cement gun claim can be sealed up. This work will be attempted by the Lehigh & New England R. R. this winter.

Temporary Building for Storage of Cement

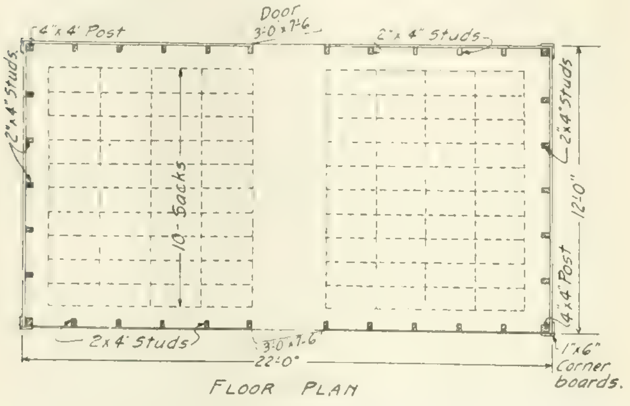
Reserve supply of any commodity in daily demand on construction work goes far toward insuring uninterrupted operation. The provision and use of adequate storage buildings eliminates the chance of temporary suspension of operations or retarded progress when transportation conditions or other unforseen contingencies delay shipment of material. To make certain the prompt start and continuous progress of construction, there is coming into more general use the practice of accumulating in storage a supply of construction material, including cement. Useful suggestions on the storage of this latter material are given in a recently issued booklet of the Portland Cement Association, to which we are indebted for the matter in this article.



Cross Section of Temporary Cement Storage Building.

Some Fundamental Requirements of Storage.—Unless properly stored, cement will soon absorb enough moisture from the atmosphere to affect its quality. It must be kept dry at all times prior to use; therefore, it should be stored in a damp-proof, weather-tight building. No matter what the condition of weather or season, the atmosphere always contains some moisture. The more nearly air-tight the storage building can be made and kept, so as to prevent influence of changing outdoor atmospheric condition, the less effect will there be on the quality of the cement while in storage.

For storage in the immediate vicinity or on the site of construction work, so-called temporary structures are usually provided. These may be of light, simple construction, yet must be built to maintain a dry, weather-proof interior. Build the floor a sufficient distance above ground to protect against ground moisture. A double board floor of tongued and grooved lumber is best, with the boards of the upper floor laid at right angles to those in the lower one, and a layer of tarred or other water-proof paper between.



Plan for Building Having Capacity for 1 Carload of Cement.

The doors in the center of each side provide easy facilities for handling cement in and out of building. When warehouse is located along railroad track where swinging doors would reduce the clearance required for safety, sliding doors should be used.

For convenience in handling the cement on the job, the floor level should be approximately 1 ft. above the switch track or driveway approach, and the space beneath the floor filled solid with well tamped cinders or gravel. Should it be found desirable to have the floor several feet above the track level, heavier construction for the floor will be needed to support the load.

The walls of a wooden shed may be made damp-proof by applying one or more layers of tar paper. A one-way roof is simple and satisfactory with tongued and grooved boards, well covered with tarred roofing paper to make it leak-proof. The roof should overhang the walls at least a foot on all sides of the building and should be so firmly secured to wall studs or framing, that there will be no danger of its being thrown off.

Windows, may be dispensed with, but if thought necessary for light, should be placed well up under the roof overhang to make them more weather-tight.

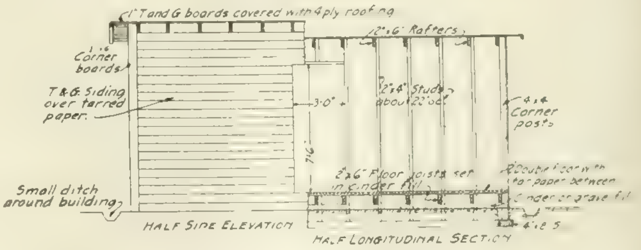
Building for Storage of One Car of Cement.—The illustrations suggest a simple, damp-proof cement storage building for temporary purposes. This has a capacity of one car but may be enlarged by adding other sections of the same size. Make the fill under the floor with clean coarse cinders or coarse gravel.

Following is a bill of material for constructing one section:

BILL OF MATERIAL FOR TEMPORARY SACK STORAGE SHED 12 FT. X 22 FT.

Item.	No.	Dimensions	Board ft.	Tot. T.&G.	Tot. rough.	Remarks.
Sills	4	4"x 8"x12'	128			
Sills	2	4"x 8"x10'	54			
Posts	4	4"x 4"x12'	64			
Studs	31	2"x 4"x12'	248			
Floor joist	13	2"x 6"x12'	156			
Rafters	13	2"x 6"x14'	182			
Flooring	12	1"x12"x14'	168			
Flooring	12	1"x12"x12'	144		1,144	
T. & G.—						
Flooring	48	1"x 6"x12'	288			
Siding	52	1"x 6"x12'	312			Ends
Siding	64	1"x 6"x10'	320			Sides at doors
Siding	14	1"x 6"x14'	98			Sides over and under doors
Siding	14	1"x 6"x12'	84			Sides over and under doors
Roofing	62	1"x 6"x12'	372			
Doors	16	1"x 6"x 8'	64	1,538		
Corners	8	1"x 6"x12'	48		48	
				1,538	1,192	

Miscellaneous items
4 8" strap hinges.
2 hasps and padlocks.
Nails.
1,200 sq. ft. 2-ply roofing (sides and floor) 12½% added.
380 sq. ft. 4-ply roofing (roof) 12½% added.


1" T and G boards covered with 4 ply roofing
2"x6" Rafters
1"x6" Corner boards
T&G Siding over tarred paper
3'-0"
2"x4" Studs about 2'-0" oc.
4x4 Corner posts
2"x6" Floor joists set in cinder fill
Double floor with tar paper between
Cinder or gravel fill
Small ditch around building
4x8 S
HALF SIDE ELEVATION
HALF LONGITUDINAL SECTION

Half Side Elevation and Half Longitudinal Section.

Note particularly cinder fill around floor joists, with two-inch double wood floor with tar paper between. Small ditch around building provides for proper drainage and will help keep dry the ground or fill under building.

Piling Sacked Cement.—When cement in sacks is stored in high piles for a considerable time, there is a tendency for that in the lower sacks to "cake," due to pressure of the sacks above. Cement that has caked from this cause can be reconditioned by either rolling or dropping the sack on the floor.

Cement to be stored for a short time only may be piled 12 or 15 sacks high, but if to be stored for a long period, piles should not be more than 7 sacks high in order to minimize caking or "warehouse set."

The cement may be piled directly on concrete floor laid on a well tamped fill of cinders or gravel, or a floor elevated above ground.

Pile sacks closely but not in contact with building side walls. No more free air space should be left than necessary, however.

When storing for long periods in permanent structures, pile about 1 ft. away from wall.

To lessen the danger of piles overturning, pile the sacks in headers and stretchers—that is, alternately lengthwise and crosswise so as to tie the piles together. However, if piles seven sacks high are laid up carefully there will be little danger of their overturning. This height of pile makes it easier to handle sacks in and out of the storage building because the hand-trucks used to move cement in the storehouse usually carry 7 sacks.

The capacity of a storehouse depends upon its floor area and the height to which sacks are piled. A sack of cement occupies a little over 2 sq. ft. of floor space and about 1.25 cu. ft. of volume space. If it is necessary to store a greater amount of cement on a given floor area, the height of pile can be increased to 14 or 15 sacks high. This is usually the maximum that can be laid up economically.

When moving cement from warehouse piles, some sacks should be removed from two or three tiers back rather than all from one tier. If the piles are thus stepped back, particularly when they are 15 sacks high, accidents due to a pile of sacks overturning are prevented.

Every contractor has problems peculiar to the conditions under which cement must be handled and stored. Methods should be selected which will be most advantageous under those conditions.

Railroad Reconstruction in France

The following details of the condition of the French railroads and their reconstruction since the Armistice have been furnished by the French Commission in the United States. Of the 2,404 kilometers of double track line totally destroyed during the war, all have been completely reconstructed. To permit normal traffic along these lines, it was necessary to wholly rebuild 1,400 signal towers, culverts and small bridges of the total of 1,503 destroyed. In addition, of the 2,785 kilometers of single track line destroyed, 1,810 have been entirely reconstructed and opened to traffic. Work on the remaining 975 kilometers is at present being carried out, but is progressing more slowly because double track line is being built instead of the single track line.

The number of locomotives in France at the signing of the Armistice in service was 14,537. On Dec. 31, 1920, this number had increased to 18,429, of which 14,827 were French, 1,679 German, 1,299 of the Pershing type, and 624 of the American Government type. Orders for 1,200 locomotives are at present being carried out. The number of freight cars at the disposal of the French railroads in November, 1918, totaled 410,308. On the 31st of December, 1920, this number had increased to 518,810, of which 432,038 were French, 48,891 German, 18,194 of the Pershing type, and 19,687 American Government type. Work is at present being carried out on 2,500 freight cars for various roads.

The figures for the railroads of Alsace-Lorraine are not included in the above total. These railroads have at their disposal 1,566 locomotives and 42,297 freight cars. They are to receive from Germany under the terms of the Peace Treaty a further 289 locomotives and 10,000 freight cars.

Placing Orders for Equipment.—Not only are the French railroads placing orders for a great deal of new rolling stock and locomotives, but they have opened new repair shops to keep their present material in good condition. In the period immediately following the Armistice, French railroad shops were able to repair 115 locomotives and 88,000 freight cars a month. In 1920, they repaired an average of 190 locomotives and 116,214 freight cars a month.

Further proof of the recovery of French railroads is given by the notable increase in traffic handled during the last three months in 1920, as compared with the last three months of 1919. The 1920 figures show an increase of 80 per cent in the number of passengers handled, of 95 per cent in the number of tons of fast freight handled and of 20 per cent in the number of tons of ordinary freight carried. As a whole, the traffic of French railroads is equal that of before the war.

Progress in Electrification.—The work of electrifying certain French roads, which started in 1920, has made rapid progress. The Midi Co. has 150 kilometers of double track electric line in operation and the work of electrifying a further 3,000 kilometers of track belonging to this road is actually in progress. The reconstruction of two hydro-electric plants, which will furnish 150,000 HP. each to this road, is nearly complete. The road has placed orders for 50 new electric locomotives of the type used by the Chicago, Milwaukee & St. Paul Ry. Two other French railroads have undertaken the electrification of sections of their line, the Orleans, which is electrifying 3,000 kilometers, and the P. L. M., which also is electrifying 3,000 kilometers of road. The electric power for the Orleans road will be furnished by the water falls of the Upper Dordogne, and for the P. L. M. by the falls of the French Alps. The cost of electrifying these roads will be in the neighborhood of 5,000,000,000 francs. The saving in coal will exceed 3,200,000 tons per annum, which, supposing the price of coal per ton to be above or equal to 100 francs, will, at the current rate at which money may be borrowed in France for such work, more than pay the interest on electrification bonds issued.

Standard Specifications for Cross Ties

At the third annual convention of the National Association of Railroad Tie Producers, held January 28 at San Francisco, standard specifications for cross ties similar to those of the American Railroad Association were adopted. The specifications follow:

MATERIAL.

Kinds of Wood.—Before manufacturing ties, producers shall ascertain which of the following kinds of wood suitable for cross ties will be accepted: Ash, beech, birch, catalpa, cedar, cherry, chestnut, cypress, elm, fir, gum, hackberry, hickory, larch, locust, maple, mulberry, oak, pine, poplar, redwood, sassafras, spruce, sycamore and walnut. Others will not be accepted unless specially ordered.

PHYSICAL REQUIREMENTS.

General Quality.—All ties shall be free from any defects that may impair their strength or durability as cross ties, such as decay, large splits, large shakes, large or numerous holes or knots, or grain with slant greater than one in fifteen.

Resistance to Wear.—Ties from needleleaved woods shall be of compact wood throughout the top fourth of the tie, where any inch of radius from the pith shall have not less than one-third summerwood in six or more rings of annual growth, or not less than one-half summerwood in fewer rings. Ties of course wood having fewer rings or less summerwood will be accepted if specifically ordered

Resistance to Decay.—Ties for use without preservative treatment shall not have sapwood wider than one-fourth the width of the top of the tie between 20 in. and 40 in. from the middle, and will be designated as "heart" ties. Those with more sapwood will be designated as "sap" ties.

DESIGN.

Dimensions.—Before manufacturing ties, producers shall ascertain which of the following lengths, shapes or sizes will be accepted, and whether ties are to be hewed or sawed and in either case whether on the sides as well as on the top and the bottom.

All ties shall be 8 ft., 8 ft. 6 in., or 9 ft. long.

All ties shall measure as follows throughout both sections between 20 in. and 40 in. from the middle of the tie:

Grade	Sawed or hewed top. bottom and sides.	Sawed or hewed top and bottom.
1.	None accepted	6 in. thick x 6 in. wide on top
2.	6 in. thick x 7 in. wide on top	6 in. thick x 7 in. wide on top
3.	6 in. thick x 8 in. wide on top	6 in. thick x 8 in. wide on top
		7 in. thick x 7 in. wide on top
4.	7 in. thick x 8 in. wide on top	7 in. thick x 8 in. wide on top
5.	7 in. thick x 9 in. wide on top	7 in. thick x 9 in. wide on top
6.	7 in. thick x 10 in. wide on top	7 in. thick x 10 in. wide on top

All other usable ties shall be classed as grade 0 ties.

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*Northern white cedar or tamarack (larch) pole ties manufactured from timber measuring 8 in. in diameter under the bark at the small end shall be classed as Grade 1

MANUFACTURE.

All ties shall be straight, well hewed or sawed; cut square at the ends, have bottom and top parallel, and have bark entirely removed.

INSPECTION.

Ties will be inspected after delivery at suitable and convenient places satisfactory to the railroad, which reserves the right to inspect ties at points of shipment or at destination. Ties will be inspected at points other than the railroad's property whenever in the judgment of the railroad there is sufficient number to warrant it; but the shipper shall provide accommodations for the inspector while away from rail or steamer lines and transport him from or to a railroad station or steamer landing.

Inspectors will make a reasonably close examination of the top, bottom, sides and ends of each tie. Each tie will be graded independently without regard for the grading of others in the same lot. Rafted or boomed ties too muddied for ready examination will be rejected. Ties handled over hoists will be turned over as inspected.

Ties will be rejected when decayed in a degree sufficient to impair materially their strength and durability, except that the following will be allowed: In cedar, "pipe or stump rot" up to 1½ in. in diameter and 15 in. deep; in cypress, "peck" up to the limitations as to holes; and, in pine, "blue sap stain."

A large hole in woods other than cedar is one more than ½ in. in diameter and 3 in. deep within, or more than 1 in. in diameter and 3 in. deep outside the sections of the tie between 20 in. and 40 in. from its middle. Numerous holes are any number equaling a large hole in damaging effect.

A large knot is one exceeding in width more than one-fourth of the width of the surface on which it appears; but such a knot may be allowed if it occurs outside the sections of the tie between 20 in. and 40 in. from its middle. Numerous knots are any number equaling a large knot in damaging effect. Such holes may be caused in manufacture or otherwise.

A shake is a separation of one ring of annual growth from another. One which is not over 4 in. long or ¼ in. wide will be allowed.

A split is a break across annual rings. One which is not over

10 in. long will be allowed pe[illegible] anti-splitting device has been properly applied.

A tie will be considered straight: (1) When a straight line along the top from the middle of one end to the middle of the other end is entirely within the tie; (2) when a straight line along a side from the middle of one end to the middle of the other is everywhere more than 2 in. from the top and bottom of the tie.

A tie is not well hewed or sawed when its surfaces are cut into [illegible] marks more than [illegible] surfaces are not even.

The lengths, thicknesses and widths specified are minimum dimensions. Ties over 1 in. more in thickness, over 3 in. more in width, or over 2 in. more in length will be degraded or rejected.

The top and bottom of a tie will be considered parallel if the difference in the thicknesses at the two sides or ends does not exceed ½ in., that is, one side may be 7¼ in., while the other is 6¾ in. wide; or one end may be 6¾ in., while the other is 7¼ in. thick.

All thicknesses and widths apply to the portions of the tie between 20 in. and 40 in. from the middle of the tie. All determinations of widths will be made on the top of the tie, which is the narrower of the horizontal surfaces.

Ties which are oversize will be accepted as follows: 8 in. to 9 in. x 9 in. to 12 in. as Grade 4; 9 in. to 10 in. x 9 in. to 12 in. as Grade 3. Ties over 10 in. thick or over 12 in. wide on top will be rejected. Ties will be graded up by their smaller ends and graded down by their larger ends. The dimensions of the tie will not be averaged.

Split redwood ties are permitted a slight variation in size, but such variations must not be more than ½ in. one way or ¼ in. two ways.

DELIVERY.

Ties delivered on the premises of the railroad for inspection shall be stacked not less than 10 ft. from the nearest rail of any track at suitable and convenient places; but not at public crossings, nor where they will interfere with the view of trainmen or of people approaching the railroad. Ties shall be stacked in alternate layers of two and seven, the bottom layer to consist of two ties kept at least six inches above the ground. The second layer shall consist of seven ties laid crosswise of the first layer. When the ties are rectangular, the two outside ties of the layers of seven and the layers of two shall be laid on their sides. The ties in layers of two shall be laid at the extreme ends of the ties in the layers of seven. No stack may be more than twelve layers high, and there shall be 5 ft. between stacks to facilitate inspection. Ties which have stood on their ends on the ground will be rejected.

Each stack shall have fastened to it a tag on which is written the owner's name and address, the date when stacked and the number of ties of each kind of wood in the stack.

All ties are at the owner's risk until accepted All rejected ties shall be removed within one month after inspection.

Ties shall be stacked as grouped below. Only the kinds of wood named in a group may be stacked together.

CLASS U—TIES WHICH MAY BE USED UNTREATED.

Group Ua.
Black locust
White oak
Black walnut

Group Ub.
"Heart" Douglas fir
"Heart" pines

Group Uc.
"Heart" cedars
"Heart" cypress
"Heart" redwood

Group Ud.
"Heart" catalpa
"Heart" chestnut
"Heart" red mulberry
"Heart" sassafras

CLASS T—TIES WHICH SHOULD BE TREATED.

Group Ta.
Ashes
Hickories
"Sap" black locust
Red oaks
"Sap" black walnut
Honey locust

Group Tb.
"Sap" cedars
"Sap" cypress
"Sap" Douglas fir
Hemlocks
larches
"Sap" pines
"Sap" redwood

Group Tc.
Beech
Birches
Cherries
Gums
Hart maples

Group Td.
"Sap" catalpa
"Sap" chestnut
Elms
Hackberry
Soft maples
"Sap" mulberries
Poplars
"Sap" sassafras
Spruces
Sycamore
White walnut

SHIPMENT.

Ties forwarded in cars or vessels shall be separated therein according to the above groups, and also according to the above sizes if inspected before loading.

How to Prevent Explosions in Compressed Air Lines.—A recent Report of Investigation of the U. S. Bureau of Mines recommends that to prevent explosions in air lines, the first consideration is to use the proper grade of cylinder oil, and, second, the compressor valves and intercooling system should be kept in good order. An aftercooler would appear desirable in high-pressure installations. Care should be taken that only fresh air be drawn through the intake of the compressor.

Present Day Problems of the Railroads*

By DANIEL WILLARD,

President, Baltimore & Ohio R. R.

There are many problems confronting the railroads, and many confronting all of us. The railroad problems are seasonal; they are periodic; and they are economic. I think, however, that the most constant and persistent problem that confronts the railroads at all times, through all seasons and all periods, is the problem that grows out of being misunderstood. The railroads are such a large undertaking and we have to talk in figures that we so little comprehend that this difficulty is ever present.

American Railway System Comprises 1,800 Separate Companies.—First of all, we talk about an American railroad system and there is not any such thing as an American railroad system in the sense that there is an American telephone system, for instance, which has wire communication under the same general control from one part of the United States to another. No one ever visualized the railroads in that sense, because their development has been quite unlike that of the telephone. The railroads helped to develop the country. The teelephone came in after the country was developed.

When we speak of the American railroad system we, of course, have something in mind, and while it is not a concrete system under one control, like the Pennsylvania R. R., we will say, it is in a general way a system that co-ordinates with itself, but is made up of more than 1,800 separate and independent companies. Now these 1,800 companies have altogether about 260,000 miles of main line. They own about 2,300,000 freight cars and about 60,000 locomotives, and something like 55,000 cars designed for passenger train service.

So far I have been able to discuss the matter and keep within terms of millions. But immediately we begin to discuss the earnings, the costs and performance of the property, we get into terms of billions. But we cannot discuss the railroad problem without talking in billions. For instance, the books of the carriers show that this great property has cost something like twenty billions of dollars to start with. It depresses many people when they think how much money we must have in the property and how much of it probably we did not get properly. It is because the size is so great that that feature is misunderstood in the beginning.

Railways Carry 448 Billion Ton Miles Per Year.—Then we try to talk about the performance of the railroads. Immediately we say they earn six or seven billions of dollars a year, and some one says that is as much as the value of all the farm crops in a certain period and consequently there must be something wrong about it. But the railroads not only carry the crops from the farms, but they perform a general service for all the people in the United States that can only be put in concrete terms when we say they carry 448 billions of ton miles a year. No one understands, certainly I do not, what is meant by this figure. I have no definite conception of 448 billions of ton miles. I can put it in another way and comprehend it a little better. For instance, it works out this way: the railroads carry 4,000 tons one mile every year for every man, woman and child in the country. Putting it another way: they carry ten tons 400 miles for each inhabitant of the country. Then in addition to that they carry billions of passenger miles, which no one undertands, but again when these passenger miles are resolved into somewhat simpler terms, they are the equivalent of 400 miles of travel annually by every man, woman and child in the country. Now when we consider the amount of traveling for every individual to me it does not seem so unreasonable when it is said the railroads tax each person, if it is a tax, some $50 or $60 a year. My own investigation leads me to think that the people get more for $50 or $60 a year which they pay the railroads, than they get from any other concern or undertaking to which they pay money.

The trouble is that we talk in such big figures all the time that no one understands what we are talking about. When we get into billions, billions become minimized. They lose their relative value. To illustrate: I saw not long ago a statement by the statistician of the director general of railroads—he was pointing out the accomplishments of federal control—and he said that one of the outstanding accomplishments was this fact: the director general [illegible] route the business so as to cut out circuitous routes which had saved the movement of 17,000,000 car miles a year. Well, 17,000,000 car miles is a great many car miles to save a year, and if we were in the habit of discussing this problem in terms of millions, no doubt it would have a relative value of some importance, but when you consider that the total car miles which the railways moved in the year was 23,000,000,000, then your 17,000,000 becomes .07 of 1 per cent.

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*An address before the annual meeting of the National Civic Federation at New York.

The Seasonal and Periodic Problems.—The other problems I have said are seasonal, periodic and economic. Take the seasonal problem. One of them which I call seasonal was the situation that confronted the railroads last summer. We had just come out of a war. There was banked up, so to speak, a great amount of goods to be moved. During the war the government had not been able to keep up increasing the facilities of the railroads. During the war there was a most prodigious increase of all kinds of productive capacity in our country. Farmers cultivated more land, old factories were enlarged, new factories were built, and all that sort of thing; but the railroads stood still. It happened that in spite of the fact that some people said they had broken down, they were, nevertheless, able to move all the things necessary to carry on the war, and consequently nothing was done to increase their facilities—that is to say, nothing of real permanent value.

For instance, the director general during the 26 months' period of federal control, bought 100,000 freight cars. Now 100,000 freight cars is a lot of freight cars, but we wear out almost a hundred thousand every year—50,000 anyway—and he bought in the 26 months only what the railroads themselves were in the habit of buying every twelve months. So you can see at the end of the war, after having sustained unusual service, the railroads were not only inadequately equipped, but their equipment was in an impaired condition. I do not speak of that to criticize at all. I am simply telling you the facts so you will understand the situation. When the roads were turned back to their owners on March 1 of last year, the owners of the properties were called upon to perform the largest service of transportation ever performed, and with this plant which had been allowed to depreciate.

During the war movement of materials for road building, for house building and for other projects not necessary in conducting the war was virtually stopped. When the war was over, everybody wanted to ship all at once. The railroads were confronted with a difficult task and their immediate problem was a very vital one, at least from the standpoint of those who favor the continuation of private ownership and control. So from that point of view, this particular problem developed last spring: Is it possible for 1,800 different railroad companies to so function and work together that they can, under private ownership with government regulation, perform in the aggregate as great an amount of service as they could perform if they were unified under one general manager or director general?

Last summer the roads—the 1,800 separate companies working together in a common interest—appreciated that it was expected of them that they should do as much as had been done with the same plant under government control. The result was that the combined tonnage carried by all the railroads was 448 billion ton miles, as I have stated. The largest sum ever carried before was 440 billions. So the railroads showed that, acting independently under the present law, they could realize the benefits of unified control just as well as they could be realized under government operation, and as a matter of fact within the same period of time and with the same plant, they carried eight billion ton miles more than the plant had ever carried before. Now, that was one of the problems. I think we got away with that problem rather successfully.

Today's Problem One of Net Earnings.—Today the railroads are looking for tonnage to carry. I suppose the business the railroads are carrying today is 30 per cent in volume less than it was last summer. And the problem now is no longer how can we give the maximum service with a given plant, but how can we obtain necessary earnings to maintain the institution of private ownership. That is the problem today. It shifts. The problem is never the same from one time to another, except the difficulty of being understood. That is always there. Today the problem is one of net earnings.

This matter brings in the cost of operation and leads us immediately to another problem, and a very important one, and that is the labor problem. . Now the labor problem is very important with the railroads because so large a part of all the money collected by the railroads is immediately paid out for labor.

60% of Gross Earnings Goes to Labor.—I suppose at the moment—but I do not know, and neither does any one else know because there are no general figures available at this time—that out of every dollar that the railroads collect at least 60 per cent is being paid out for labor. Before the war that percentage used to vary around 40 to 45. It gradually got up to 60. It is too high. It must come down. Just how it is going to be worked out, I do not know. The railroad rates are as high probably as they ought to be and certainly no one could recommend that they should be raised any more at this time. Still it is a matter of common knowledge that with the rates high as they are, many of the important railroads today are not earning their operating expenses and very few are earning their full interest at the present time.

Now. of course, that cannot go on as a permanent thing, and if the rates cannot be increased and the volume of business does not increase, then the cost of doing business must be reduced, or the scheme will fail. I do not think the scheme will fail. I expect business will gradually get some better and finally get back where we would like to see it.

I am not one of those who wants to see conditions back as they were before the war. Take the labor matter. Before the war, it was generally recognized that railway workmen were relatively not receiving as high wages as workmen in other undertakings. There are reasons for that which I need not go into. But the difference became accentuated as we got into the war. Some of the wages of the workers in effect today—many of them perhaps—will probably have to be readjusted downwards. I do not think that the time has come for that as yet. But there is a matter in connection with the labor of the railroads that is demanding serious thought. During the period of federal control the so-called National Agreements were entered into between the director general and the mechanical crafts.

In the working out of those National Agreements conditions arose which, in my opinion, are not right at the present time—if, indeed, they were ever right. The attitude of the railroads before the Labor Board is that those features in the national contract which have the effect of, we will say, discouraging efficiency—have the effect of paying men for work that is not performed—should be eliminated. It is a general thought, too, that the unskilled laborers upon the railroads are perhaps being paid more now than is justified under all the circumstances, because we must bear this in mind; whatever the wages paid by the railroads are, the public must pay through rates and charges. Not only that: if the public should be willing to maintain a rate of wages that is unreasonably high for a certain class of workmen, then the farmers and other employers of the same kind of labor would be obliged to pay similar wages, and that gets into the cost of living. No one wants to see any workman working for a wage that is not fair and is not reasonable, considering all the circumstances.

We will save a considerable sum of money in the purchase of supplies, the price in that connection having gone down materially in the last two or three months. The railroads are reducing their forces now because it is found with a lesser volume of business that so many men are not necessary, and then the older men who are coming back to their original jobs are more efficient, and fewer men do more and better work. This is enabling the railroads to reduce the labor charge somewhat.

Esch-Cummins Act and Private Ownership.—Now there is only one other problem I will speak of just now, although I might refer to many. That is the problem which must be ever present in the minds of those who favor private ownership and control of the railroads. It is this: does the Esch-Cummins Act make private operation possible? I believe it does. Whether private ownership and operation of the roads continue or not depends upon whether the people want it to continue, and will be satisfied with the service the roads give them. It gets back to the railway managers themselves. If they give the public a service that measurably meets the public requirements, then I believe the public will want private ownership to continue.

I think that perhaps what I have said is sufficient to give an indication of some of the problems that the railroads are trying to overcome at the present time. The most important of all is the difficulty of being understood.

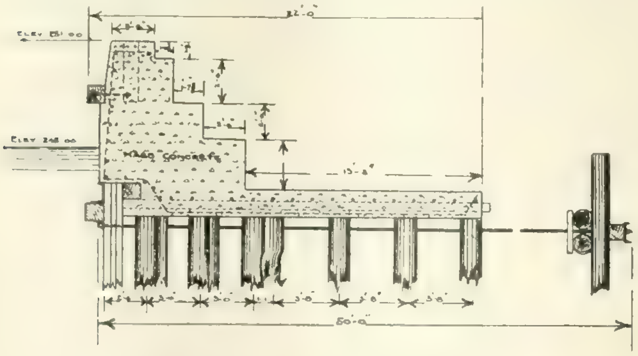
Retaining Walls for Toronto, Ont. Harbor Development

One of the most interesting features of the harbor improvements at Toronto, Ont., from an engineering standpoint is the construction of the retaining walls. By making these confining walls of modern wharf construction the reclaimed areas were placed immediately adjacent to dockage facilities. The following details regarding these walls are abstracted from a paper on the Toronto Harbor Improvements presented Feb. 3 by Edward L. Cousins at the general professional meeting of the Engineering Institute of Canada.

The type of wall adopted depended largely on the depth of rock below mean water level. This was due to the fact that the development was to provide for an ultimate navigable depth of 30 ft. On this account, when the depth to rock was in the neighborhood of 30 ft. a crib type of wall was necessary; where the depth to rock was 40 ft. or over, a channel 30 ft. deep could be dredged, and there would still be left 10 ft. of material for penetration of piling, and in such cases the pile type of wall was adopted. The Ship Channel wall is an example of the latter type, and the Harbor Head wall of the former.

Ship Channel Walls.—The ship channel wall consists of tongued and grooved close sheet piling of British Columbia fir made up of 12-in. x 12-in. timbers with strips spiked to both sides forming close sheet piling. These piles are 40 ft. long and are driven in front of the structure. They are cut off squarely and evenly at the level of the top of the substructure elevation, namely, at elevation 243.0 ft., or 2 ft. below the zero of the Harbor Commission gauge.

Two stringers run along the top of the close sheet piling, one on the rear face and one on the front face, the two stringers being tied together by 1-in. bolts. The rear stringers are of timber and the face stringer is a 15-in. steel channel.



Section of Ship Channel Walls.

Pile bents driven at right angles to the line of the work form the foundation for the wall and brace the wooden sheet piling. The spacing of all bents longitudinally is at 5-ft. centers. These piles are of spruce 14 in. diameter at the butt end and 8 in. at the point. Cap timbers are of 6-in. x 12-in. hemlock and securely drift-bolted to the top of each pile.

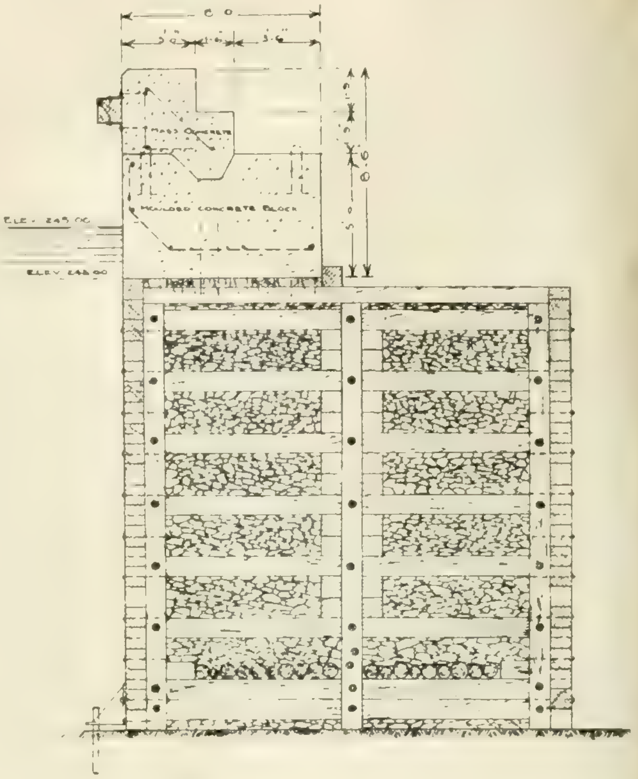
The concrete superstructure was originally intended to consist of reinforced concrete blocks, upon which was to be superimposed a mass concrete top. The work was actually carried out, however, by constructing a dam across the west end of the channel and lowering the water in the Ship Channel to an elevation approximaately 8 ft. below the lake level. This enabled the contractor to cut off all piles, set the cap timbers, and place the entire concrete superstructure in the dry. It also made possible a closer inspection of the various steps in the progress of the work. The concrete was mixed in the proportions of 1 of cement, 2 of sand, and 4 broken stone or an approved grade of gravel. It was moulded in 50-ft. longitudinal sections with proper provision for contraction at each joint.

Anchor rods were placed on 10-ft. centers along the superstructure. The rods are 2-in. in diameter, 50 ft. long and extend from the front face of the timber sheet piling back to anchor piles driven at 2-ft. centers. Turnbuckles are provided on each rod.

Cast iron bollards of the Scotch type are provided on the face of the ship channel and turning basin walls and are spaced 75 ft. apart.

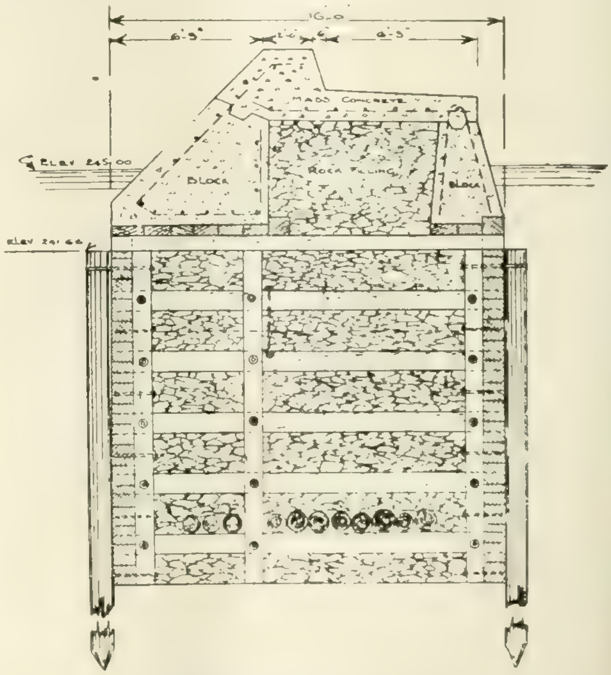
This type of wall was used for the construction of the ship channel, turning basin, circulating channel, marginal way walls, and a portion of the Don River retaining walls. The balance of the Don River wall and the retaining wall at the Humber River were of the same type except that steel sheet piling was used instead of timber sheet piling.

Harborhead Walls.—The other type of wall used in connection with the development work was the crib type. This was used in the construction of the harbor head walls from Bathhurst St. easterly to York St., which have been completed, and from York St. to Yonge St., which are under construction.



Section of Harborhead Walls.

This structure consists of rock filled crib work in sections of standard lengths of 100 ft., and special lengths as required to make up odd distances. The section of these cribs in general is square, varying from 18 ft. to 26 ft. by 2-ft. intervals. In addition to the timbers shown on the general cross section, longitudinal ties were placed in all cribs over 24 ft. in width.



Section of Western Breakwater.

Berths or trenches were dredged to bed rock. The rock surface was made even and regular, and of sufficient width to provide an even bearing for the cribs throughout their entire length and breadth. Before placing the cribs the rock was cleaned and leveled, and careful soundings taken in order that the crib would be constructed to fit the bottom accurately.

After being sunk and held in position by sinking blocks, the cribs were filled with stone of a quality as hard and durable as good building limestone. The various sections of crib work were fastened together by interlocking end posts.

After the cribs were sunk in position, lined, filled with stone and allowed a reasonable time for settlement, the vertical posts were cut off and capped and the flooring laid to receive the pre-moulded concrete blocks. The elevation of the top of the wooden structure is 24 ft.

The superstructure consists of pre-moulded concrete blocks 8 ft. x 5 ft. x 5 ft. with sides beveled front to back, thereby making possible a perfect alignment. After being placed and lined, the blocks are keyed to the plank flooring and also to each other. The concrete mass as shown in section is placed on the blocks and tied to the latter by reinforcing steel. Contraction joints are placed at every 50 ft., and mooring bollards every 75 ft., as in the case of the other walls.

This type of wall was also used in the construction of the extension of the exhibition sea wall and the western breakwater. The latter is a structure 18,500 ft. long extending from Bathurst St. to the Humber River. It is being built to serve a three-fold purpose, (1) to prevent erosion of the shore, (2) to provide a protected waterway for pleasure craft, and (3) to raise the temperature of the water behind it for bathing purposes.

Progress of American Engineering Council Committee on Elimination of Waste in Industry.—The work of the Committee on Elimination of waste in Industry of American Engineering Council is well under way. A definite scheme of operation went into effect on Feb. 7, and on Feb. 21 reports on the first investigation in each industry were made. The chairman of the committee is J. Parke Channing of New York and the vice-chairman in active charge of the inquiry is L. W. Wallace, executive secretary of the council. The work of the committee is being directed from temporary headquarters in the Engineering Societies Bldg., New York. The field work, covering principally New York, New England, and Pennsylvania, will, Mr. Wallace announces, be completed by April 1. A meeting of the planning board was held on March 1. Preliminary reports were presented and further plans were made for continuing the investigation more intensively. These reports were uniformly encouraging and there is every reason to believe that the investigation will yield information that will have an important bearing on the nationwide movement inaugurated by the engineers to wipe out waste in American industry. Among the industries now under investigation and on which reports from field workers have been received are coal, transportation, clothing, shoes, printing, textiles and the metal trades. The committee consists of J. Parke Channing, chairman; L. W. Wallace, vice-chairman; Robert B. Wolf, J. H. Williams, H. R. V. Scheel, Fred J. Miller, Robert Linton, C. E. Knoeppel, and Herbert Hoover. L. P. Alvord, George D. Babcock, F. G. Coburn, Morris L. Cooke, Harrington Emerson, Ira N. Hollis and E. E. Hunt are also members of the committee.

Quarry Accidents in United States in 1919.—According to reports received by the U. S. Bureau of Mines from quarry operators throughout the United States, there was a slight decrease in the fatality and injury rates at quarries in 1919 as compared with the year before. The records show that 1.93 men were killed and 144.20 were injured out of every thousand workers employed in 1919, and 2.11 killed and 147.07 injured per thousand employed in 1918. The rates are based upon the number of men reported employed, and are converted to the equivalent number of 300-day workers. The figures for 1919 are based on returns from 1,724 operators who actually worked their quarries during the year. The number of employes reported was 75,505, of whom 123 were killed and 9,199 injured. The quarries were operated an average of 253 days or a period of time equivalent to 19,138,308 man-days for all employes. The latter figure indicates an increase in the working time of more than 7 per cent over the previous year, thus making the slight decrease in the fatality and injury rates during 1919 all the more gratifying.

Coal Mining on a Co-operative Basis

Numerous attempts have been made to organize companies for the operation of mines on co-operative terms, but in the majority of instances such efforts have resulted in utter failure. One of the few mines that have been operated successfully on a co-operative basis is the Keely mine at Dugger, Ind. The operation of this mine as a co-operative commercial enterprise is described as follows by Mr. J. J. Bourquin, Mining Engineer U. S. Bureau of Mines, in a February report of investigations of the Bureau:

This shaft mine is developing 130 acres of coal in the Indiana No. 6 bed, which here averages 5½ ft. thick and lies about 110 ft. below the surface. Thirty-seven miners and 20 company men or day men are employed, and the daily output is around 300 tons. Practically the entire production is sold by contract for railroad use. No mining machines are used and all coal is produced by pick work.

The mine was originally owned and operated by the Stockton Coal Co. of Dugger, but about 8 years ago it was leased to Mr. Roy Price. He sub-leased the property to 10 miners, who formed an association known as the Dugger Mutual Coal & Mining Co., to work the mine co-operatively.

At first many difficulties were encountered; the co-operative idea is an old one, but the practice was new to those interested. Some of the men were energetic, ambitious workers; others were inclined to let their associates produce the coal but wanted to share in the profits. In time, after a hard struggle and many changes in the personnel of the company, business-like methods were adopted and the mine was put on a paying basis.

The company is not incorporated, but is licensed as a partnership organization. Thus, legal responsibility for any indebtedness incurred rests both on the company and its individual members. Only men who actually mine and load coal are eligible to partnership. The day men are paid according to the prevailing wage scale of the district. Whenever it is deemed advisable to admit more miners, men who are already employed in other capacities are given preference. On assuming the duties of miners, they become partners in the company and are entitled to a share of the earnings. Before beginning the work as a miner, each man must sign an agreement to abide by the rules and regulations of the company.

All business transactions are handled by two committees—a Finance Committee, of three members, and a Policy Committee, of five members. Each member of the company has a vote in the election of members to these committees.

The superintendent of the mine is paid a monthly salary equal to one-tenth of the sum of the earnings of the 10 miners receiving the highest pay for the month. This naturally encourages closer supervision and efficiency on the part of that official.

All employes are paid every two weeks, as is customary throughout the district. In calculating the earnings due each miner, the following method is employed:

Assume a period of 14 days' operation, 37 miners constituting the partnership. If all the miners had worked every day the operating expense per man would be calculated on the basis of 37x14, or 518 man-days. However, assume that only 23 miners had worked every day, 7 miners had worked 12 days, 4 miners 8 days, 2 miners 7 days, and 1 miner 3 days. Then the actual number of man-days worked was 455, and 63 man-days were lost during the 14-day period. Suppose that 10 of the 63 man-days were lost because of illness, and the remaining 53 man-days were lost through other causes. These 53 man-days lost through causes other than illness would be added to the 455 man-days of actual work, making a total of 508 man-days on which the daily operating expense per man would be prorated. In other words, if a miner is absent from work because of illness, he is exempted from paying any part of the operating expenses incurred during the period of his illness, but if a miner is idle through any cause other than illness he must bear a proportionate part of the expenses incurred during his absence. This plan, which is undoubtedly fair to all, was originated to discourage idleness and evidently accomplishes its purpose, for the miners are steady workmen.

The royalty fees are determined from the total tonnage of the mine for the given period. Next the number of tons of coal used in the boiler plant during that period is divided by the number of partners, and the quotient represents the tonnage that is deducted from each miner's total production for the period under consideration. For example, if there were 37 partners and 111 tons of coal were used in the boiler-house, then 111 divided by 37, or 3 tons would be deducted from the production of each miner.

The wages of day men, the sales commissions, royalty fees, and other overhead expenses are deducted from the gross income derived from sales of coal during the given period. The remainder represents, of course, the net earnings of the mine. This sum is prorated to the partners according to their respective net tonnages of production, exclusive of boiler-house coal. By this method each man shares in the profits of the company according to the amount of coal he produces.

At the time of writing, the scale rates for driving entries, cross-cuts, or break-throughs in the Dugger field was $1.884 per yard for wide work and $3 per yard for narrow work. Miners working at the Kelly mine on co-operative terms were paid $2.75 per yard for wide work and $3.90 per yard for narrow work. These prices are said to be based on calculations involving the ratios of rates paid per ton for loading coal in mines where the scale prices prevail, to the average price the men are making per ton for loading coal under the co-operative plan. Similar methods are followed in adjusting rates for driving through rolls, cleaning up falls, taking down slate, etc.

The company proposes to purchase the property that it is now working under lease, and, on each pay day assessments levied for that purpose are deducted from the earnings due the several partners. An emergency fund or reserve fund is also maintained by assessing each member of the company a small amount from his semi-monthly pay. In case a partner decides to sever his relations with the company, his earnings are paid up in full and his share of the company stock for which he has paid by assessments is refunded. It is said that there is always a waiting list of day workers eager to take the place of any miner who resigns.

The Keely mine is located in a field which has been strongly organized by union labor and only union labor is employed in or about the mine. Trouble arises occasionally among the day men in this mine as elsewhere, and when these troubles could not be settled between the day men and the committee representing the company, strikes have occurred. Under such circumstances all work is stopped, the miners who comprise the partnership under which the mine operates put down their tools and come out with the strikers, and the mine is idle until the differences have been arbitrated by the executive board of the miners' union.

The following example is a concrete illustration of the benefits that an individual miner derives under this co-operative plan. On a recent pay-roll account, one miner was credited with a net production—less boiler-house coal—of 97 tons on which his share of the mine's earnings for the given period was based. The tonnage deducted for boiler-house coal was not made known, but is believed to have been small. After deducting the sum of $18, which was applied on the purchase fund and the emergency fund, and which increased the value of his share in the property, this miner was paid $127. His entire earnings were, therefore, $145. A miner loading an equal amount at other mines in the district, paying the usual scale price ($1.08 per ton), would receive only 97 × $1.08, or $104.76, plus a small difference equal to the deduction for boiler-house coal, and would have to pay his own expenses for powder, fuse, etc.

Safety in Structural Demolition will be discussed at a meeting of the American Society of Safety Engineers, to be held at 8 p. m., March 25, in Room 1101, 29 West 39th St., New York. All those interested in this subject, especially contractors and builders, city, state and insurance inspectors, are invited to attend the meeting. The importance of reducing the number of accidents to workmen engaged in structural demolition and ways of accomplishing it will be shown by the following speakers: Hugh Frayne, General Organizer American Federation of Labor; Frederick C. Kuehnle, Chief Inspector of Buildings, Manhattan; Peter Spence, New York State Labor Department; Albert A. Volk, President of the Albert A. Volk Co., Inc.; W. E. Welch, Senior Contract Inspector, Travelers Insurance Co. Open discussion will be invited and recommended practice considered with a view to adopting standards.

Land and Right of Way Valuation Methods of the Interstate Commerce Commission

Maps and Records for Use by Appraisers.—In each case the commission is furnished by the road with a statement of land owned or leased and with a set of maps covering it. The maps contain both right of way and track data, but the requirements for right of way purposes are very simple. Briefly they are as follows: that the sheets measure 24 by 56 in. and have a ½-in. border; that for rural right of way the scale be either 400 ft. or 200 ft. to the inch, and for urban property or station maps that it be either 100 ft. or 50 ft. to the inch. (Nevertheless, in order to save the roads the expense of redrawing, other scales are accepted when the maps involved adequately exhibit all that is required); that widths of right of way and station numbers be marked in figures at each end of the sheet and at all points of change of width; that each separate tract acquired be shown and numbered; that a schedule be given, listing the tracts serially by number and furnishing references to records, deeds, grantor and grantee, leases, franchises, ordinances, grants, and all other methods of acquisition; and that intersecting divisional land lines (section lines, city limits, etc.), be shown on the map. Other information specified as desirable, but not positively required, includes intersecting property lines of adjacent landowners, and section lines, city limits, etc., for a distance of not more than one mile outside the right of way.

Classification by Zones.—The appraiser first divides the right of way into zones on the basis of his inspection of it and adjoining lands. The zones are numbered consecutively and each is classified by an appropriate title such as "swamp," "wet pasture," "farm land," "timber land," etc. The classification is not prescribed and is left to the discretion of the appraiser. Zone boundaries are marked in approximate position on blue print copies of the maps, and each zone is numbered.

Locating the Position of Zones on the Map.—Since the map contains, in addition to right of way information, a large amount of track and other data such as switches, sidings, railway buildings, mile posts, signals, bridges, culverts, drains, road crossings, etc., the appraiser can usually determine his position with all necessary accuracy without special measurements.

Method of Determining Value.—Rural right of way is appraised in accordance with the value per acre of adjacent lands of similar character, but urban property is estimated upon a square foot basis. No utility factor is applied, the value per unit of area being based upon the presumable use of the property for other than right of way purposes.

Three sources of information are used in determining fair unit values—records of recent sales; the opinions of land dealers, of bankers, who have land values as security for money loaned, and of any others who have knowledge of the value of the lands in question, or of similar lands; and finally the records of the tax assessments of comparative property.

There is no fixed rule for estimating the weight of relative value of the three classes of information, but the appraisers are required to use the judgment which their status as experts warrants. It is said, however, that the least consideration is usually given to assessments, since these are subject to many notorious inaccuracies. Obviously opinions must be sought with careful reference to the individual; and even then, a weighting of opinion may be necessary—as when there is a wide discrepancy between two statements of the same or similar lands. Neither are sales as exhibited in official records to be blindly relied upon, and it is the practice to verify the record by obtaining definite statements from the buyer or the seller or both to determinue whether or not the recorded price was of fictitious character.

Division Between Field and Office Work.—Only the limits of right of way zones and other tracts together with the appropriate unit values are reported by the appraiser. The calculation of areas, and extensions to total values, tract by tract are all performed in the office. Urban lands are zoned only according to value, and without any such classification as is applied to rural property.

Forms Used.—A few simple forms are used, and in so far as practicable these are made of standard letter size punched for 3-hole loose leaf binder. Interesting are [illegible] forms on which unit valuation data are recorded. A separate form is provided for each of the previously described classes of data. Space at the top of the sheet is provided for the zone number as well as the name of the railroad, state, county, and valuation section in which the property is located.

The form entitled "Sales Record of Similar Lands" has the following columns: Grantor, Grantee, Description, Date, Book, Page, Area, Consideration, and Unit Price.

The second form is entitled "Local Opinions of Values and Similar Lands," and has column headings: Name, Address, Occupation and Unit Value. The zone number to which these data apply appears at the top of the sheet.

The third form is headed "Latest Assessments of Similar Lands," and has columns as follows: Description, Year, Area, Assessed Value, Per Acre, Per Square Foot, Established Ratio, and Resulting Value.

Effect of Electric Traction on Economies of Railway Location

In a committee report submitted March 16 at the 22nd annual convention of the American Railway Engineering Association, the sub-commitee on "Economics of Location as Affected by the Introduction of Electric Locomotives," states that the effect of new elements introduced by electric traction upon economic values indicates that the values heretofore assumed under classified heads of Distance, Rise and Fall, Curvature and Rate of Grade will be affected. The report discusses these elements as follows:

Distance.—Train wages, fuel and repairs are the largest single items of expense, which vary with distance. The first is but little affected. A new additional charge is created for the operation and maintenance of power stations and of transmission and distributing systems.

Fuel is materially affected, the saving being from 50 per cent to 70 per cent, depending upon class of service. Engine repairs are also reduced—possibly 50 per cent. Track maintenance will under present conditions be generally increased, not only by the additional charge for the maintenance of overhead or third rail contact and distributing systems, but also by the destructive effect upon rails and fastenings of the greater impacts, due to the imperfect cushioning of the heavy weights of the electric motors.

Rise and Fall.—The unit values of the several minor classifications under this head will be determined as before with modified factors of cost. Two new elements will be introduced and must be included in the final results, viz.: the time and temperature limitations of the electric motor and the possibilities of regeneration of power on descending grades. The cost of Rise and Fall will be reduced if advantage is taken of opportunities for the regeneration of power by trains on descending grades. The value of such regeneration is considerable under proper conditions. The actual percentage of power which can be utilized will depend upon the length and steepness of incline, total length of electrified section and the number and distribution of daily trains. Regenerative braking does not become eocnomical except on long mountain grades.

Curvature.—The effect of a change to electric operation as affected by curvature, will be in degree rather than in kind, with the possible exception that the shorter rigid wheel base of some types of electric locomotives will result in reduced resistance and wear of wheels and rails.

Rate of Grade.—The effects of rate of grade and of rise and fall are more closely inter-related in electric than in steam operation. Train tonnage ratings in steam service over lines of moderate grades are often determined by the average resistance of the division and the boiler horsepower of the engine rather than by the resistance of the maximum grades. If the inherent characteristics of the electric motor permit the development of higher speed and horsepower, within its nominal rating, then the resistance of the maximum grade may become the limiting factor, and its rate becomes economically important.

In heavy service, and especially on mountain grades, the economic value of electric operation may be quite high, as it is possible to add engine units without adding engine crews.

Other differences affecting unit costs differ more in degree than in kind.

Marine Borers in San Francisco Bay

About seven years ago it was noticed that the activity of marine borers in San Francisco Bay had become of considerable importance, and it was but a few years later until failures of various dock structures indicated that a study of the problem needed to be made. In July, 1920, a committee, under joint co-operation of the Forest Products Laboratory and the American Wood Preservers' Association, was appointed and started an investigation. The result of this investigation, presented at the annual convention of the association in January, shows that the teredo navalis borers have invaded San Pablo Bay, Suisun Bay, and up the San Joaquin River 25 miles above Carquinez Straits and 50 miles from the Golden Gate, and up the sloughs of the Delta to Dutton.

This progressive invasion was the direct result of the continued shortage in the annual rainfall and run-off during these years, which permitted the settling of the larval stages on unprotected piling during the breeding season of midsummer and the survival of the borers in the wood during the brief season of the spring freshets of these years. In the upper bay from Pinole through Oleum, Mare Island, Vallejo, Crockett, Port Costa, Benicia, Martinez, to Mococo and Avon, the destruction of piling by this teredo in the summer of 1920 reached a climax which left little or no untreated piling undamaged and not a little of it wholly destroyed by penetration to the center or near it, at the mud-line.

Other marine borers, the xyotrya, limnoria, and sphaeroma, have made inroads nearly as bad.

The following is taken from the committee's report:

There is one outstanding feature of the present outbreak of marine borers in San Francisco Bay and of this survey which affects state and Federal supervision of navigable waters and of shipping and engineering practice in the construction and maintenance of marine structures, such as wharves, moles and piers. It is this, namely, that within the area infested by marine borers all unprotected woodwork is a potential breeding ground for harboring these pests, increasing their numbers, and sending forth their migrating larvae. In every case an infected bit of wood is a contagious spot. A single infected pile in 25 ft. of water and its 100 sq. ft. of surface affords shelter for upwards of 150,000 teredos, and each of these is capable of producing more than 2,000,000 larvae per year. Each pile, barring the death rate of larvae, thus produces enough young to seed 2,000,000 other piles.

Conclusions Based on the Investigation.—Marine borers are very active in San Francisco Bay, and in places where their attack is severe will destroy untreated piling in as short a time as six to eight months. In other places the untreated piling may last two to four years.

The information secured indicates that it is reasonable to expect a life of five to eight years from paint and batten protections if the work is well done. If it is not well done or if the covering is damaged by careless handling this range of life cannot be expected.

When carefully handled so that there is no injury extending through the shell of treated wood within the water section, it appears possible for properly creosoted Douglas fir bearing piling to give a life of 25 to 30 years in San Francisco Bay.

Most of the attack on creosoted piling by marine borers, which the committee has observed throughout this survey, appears to have begun in spots where untreated wood has been exposed by damage in handling the piles or placing the superstructure. It is urgently recommended that improvements be made in the methods of handling creosoted piles and building structures upon them, so that damage to the surface of the piles may be reduced to a minimum.

Precast reinforced concrete piles and pile casings have not been in use in San Francisco Bay a sufficient length of time to determine their ultimate life. A detailed examination of those structures which have been in service for 10 years shows no evidence of deterioration and they seem capable of a long further life.

Cast in place concrete pile jackets and cylinders may be expected to give satisfactory results if properly constructed of suitable materials. The difficulties of this type of construction, however, are of such a nature that the probability of securing a maximum length of life is less than in the case of precast concrete piles or pile coverings.

The selection of a type of piling or pile protection for a given structure must be made upon the basis of cost and permanence of the materials under consideration, the character of the structure and the probable need for future alterations to meet the changing requirements of commerce. When a comparatively short increase over the life of green wooden piling is sufficient, the surface protections will often be found economical in waters not exposed to severe storm action; if a moderately long physical life approximating the average economic life of marine strutures in this harbor is desired, a good creosote treatment will provide it at the lowest annual cost so far as present knowledge goes; if conditions warrant building for the greatest permanence, with less regard for the first cost, concrete construction may be useful. For the protection from further damage of wooden piles already in place and showing attack by borers, not yet severe enough to require condemnation, the concrete casing, precast or poured in place, is the only means of salvage so far found by the committee.

Reclaiming Repair Rail by Resawing

It has been the policy of the Baltimore & Ohio R. R. to lay new rail out of face on important high speed passenger divisions and those carrying heavy traffic, renewing the worn rail, which is often of lighter weight, and relaying the repair rail on branch lines where the passenger movement is less frequent and speed considerably lower, or on such branch lines where the traffic consists almost entirely of slow, heavy, freight trains. In relaying the four different weights and sections, each has been assigned to some one branch line, consideration being given to traffic over that line. In relaying the sawed end rail on branch lines, it is laid with new bolts and bars. In resawing the rail 15 in. is cut off each end of the rail. After the rail is resawed it is 30½ ft. long and is redrilled. When this sawed-end rail is laid on branch lines, the bad features of worn surface and line bent at ends and worn angle bars are entirely eliminated. The following particulars of the resawing methods are taken from a committee report submitted at the 32nd annual convention of the American Railway Engineering Association:

When the relay rail arrives at the saw loaded in cars, the cars are placed on a siding back of the saw from which the rail is handled from the cars by a stiff leg derrick onto the skids. As the cars are emptied they are shifted to the siding in front of the saw, where they are loaded with finished rail.

After the rail is unloaded on the skids, it is handled by the stiff leg derrick, with the assistance of four laborers, to the saw table. The rail is then sawed by friction saw, one end at a time. After both ends are sawed it is moved on rollers by hand to the double drill presses, where it is drilled. In drilling, the ends of four rails are drilled at one operation. The burrs are knocked off by the men handling the rail from the saw to the drill presses and at the drill presses.

The organization used at the rail saw is as follows:

1 Foreman in general charge of all work.
1 Engineer.
1 Fireman.
1 Sawman.
4 Laborers, handling rail from the skid to the saw. Of these four laborers one runs the air hoist, one handles either end of the rail, and the fourth handles the hooks.
2 Laborers, handling rail from the saw to the drill press skids.
4 Laborers, handling rail to drill press.
4 Laborers, handling rail to drill press.
1 Laborer, straightening sawed rail in car.
Total, 19 men.

During 1920 there were sawed a total of 499,137 ft. of the four different sections, namely, 85 A.S.C.E., 90 R.B., 100 R.B., 100 A.S.C.E. This represents the total number of feet of rail after it is sawed and drilled and is equivalent to a tonnage of 7,192 tons. In the sawing of the rail there was about 8 per cent lost which will be sold as scrap.

The average cost of sawing this rail during 1920 was $1.27 per ton. This cost includes all labor for unloading the rail at the saw; the labor and other direct costs incident to the actual operation of sawing the rail, and the labor cost of loading the rail onto cars. This cost does not include the labor costs of loading the rail for shipment to the saw or the unloading of the sawed-end rail on the ground for laying. The loss on account of sawing off the ends of the rail or its credit when sold as scrap is not considered in the average cost.

The Hudson River Vehicular Tunnel

An engineering project of great importance to New York and New Jersey was officially started last October by a ceremony of breaking ground, and the work is now in progress toward the building of a vehicular tunnel under the Hudson River, in order to provide an improvement over the existing ferry-boat service, and to relieve the cities from the danger of being prevented from crossing the river on account of boatmen's strikes.

The following is taken from an account of this proposed work in the Railway Review:

The program outlined for the construction of the tunnel divides the work into several contracts, so that advantage may be taken of any future decline in the cost of materials and labor, and also that the entire project may be completed at the earliest possible date.

On October 1, 1920, Contract No. 1 was awarded to the Holbrook, Cabot & Rollins Corporation, for $650,802. This contract includes the construction of two shafts in New York City, one in Canal St., near Washington St., and the other in Spring St., near Washington St.; also the care and support of the adjacent buildings, the by-passing of subsurface structures and the relocation of the New York Central R. R. tracks in Canal St. The shafts are to be structural steel caissons sunk by the compressed air method to approximately 60 ft. below the street surface.

The plans for the construction of the land shafts in New Jersey have been prepared, and it is expected that this work will be placed under contract soon. It is planned to place the river section under contract during the coming summer, and the construction of the approaches are to follow so as to insure the completion of the entire project by December, 1924. The plans for building the tunnel have been prepared under the direction of Mr. Clifford M. Holland, chief engineer for the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission. The cost of the work is to be met jointly by appropriations of the legislatures of the states of New York and New Jersey. The estimated cost of the tunnel structure above is $22,262,000, divided equally between the two states, and the time required for completion is 3½ years.

The plan of construction adopted provides for twin cast-iron tubes, each 29 ft. external diameter, to accommodate two lines of traffic in each direction with a 20 ft. roadway and a 2 ft. sidewalk in each tube. A typical cross section of this tunnel is shown in the cut.

The design follows closely that of the usual shield-driven subaqueous tunnel, in that it consists of successive cast-iron rings bolted together with an inner lining of concrete. The experience obtained in driving other tunnels is applicable to this tunnel, and it is felt that the methods heretofore used insure the successful completion of this plan of constructing.

The southerly tube for east-bound traffic extends from Provost St. and 12th St., Jersey City, under the Erie Railroad yards, the Hudson River and Canal St. to Varick St., New York; and the northerly tube for west-bound traffic extends from Broome St., midway between Varick and Hudson St., in New York, curving to the west under private property to Spring and Hudson St., and under Spring St. and the Hudson River, the Erie and the Delaware, Lackawanna & Western Railroad yards to 14th St. at Provost St., Jersey City.

The maximum adverse grade for west-bound traffic is 3.5 per cent, for east-bound traffic 3.53 per cent. These grades are comparatively short, extending only from the portal to the point where the tunnel roadway meets the street grade. To reduce congestion and to facilitate the movement of traffic at these points the width of roadway has been increased so as to accommodate three lines of traffic. The long adverse grade from the pierhead line to the portal on the New York side is 3.13 per cent, but on the New Jersey side it does not exceed 2.83 per cent.

The cast-iron tubes are constructed by bolting together successive rings of cast iron 2 ft. 6 in. wide. Each ring is made up of 14 segments approximately 6 ft. long and a key 1 ft. long. In each ring there are 85 bolts on the circumferential joints and 75 bolts on the horizontal joints. The diameter of the bolts is 1¾ in. The weight of the cast-iron lining through sand and part earth and part rock excavation is 8 tons per linear foot, while through the silt, in order to increase the weight of the tunnels, it is 8½ tons per linear foot.

Inside the cast-iron lining there is an inner lining of concrete 19 in. thick, extending to a point 7 in. beyond the flanges of the rings. The surface of the concrete is to be rubbed and painted so as to provide a smooth surface which can be kept clean. The use of glazed tile was considered, but it was not adopted on account of its cost.

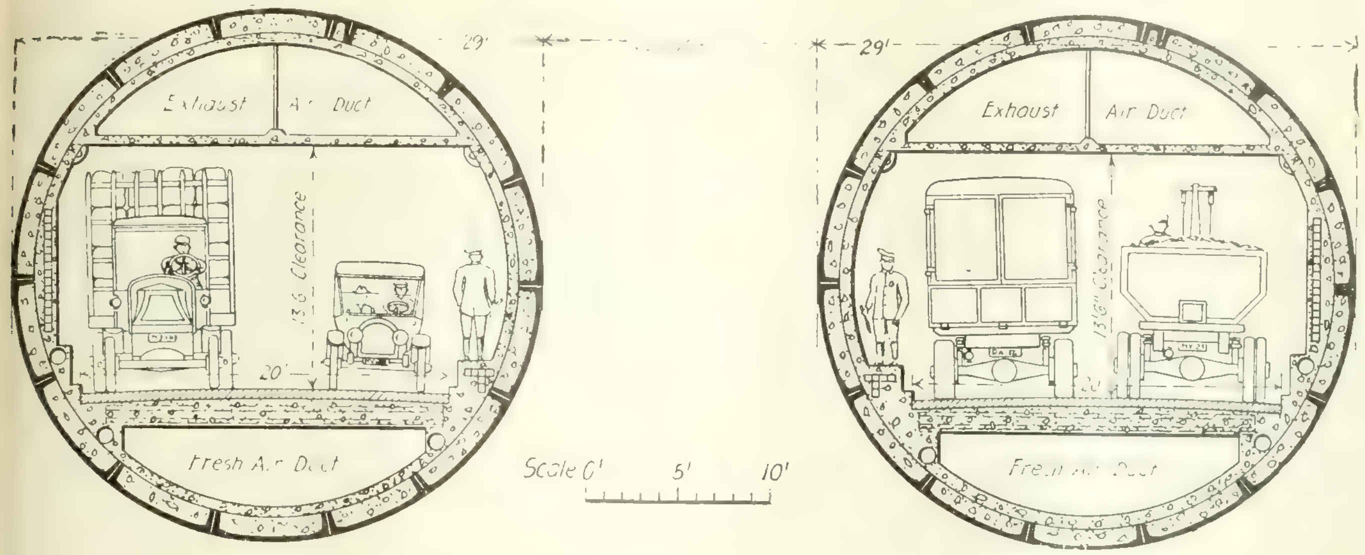
Why the Trench Method of Construction Was Not Adopted. The trench method of tunnel construction has been carefully studied as an alternative plan, but its success and cost depend largely upon several unknown factors which have been discussed as follows:

A consideration of the greatest importance is the interference with river traffic. The floating plant required for this method of construction would be continuously endangered by the great volume of river traffic due to the possibility of collisions under ordinary conditions which would be greatly increased by storms, fog and ice. From the records of the United States Engineer's office in charge of dredging operations in the irver in the New York City district it is found that during 1918 and 1919 two dredging outfits, working under the direction of that office, in the East River, suffered 62 accidents, five of which caused delays varying from 5½ to 46 days.

The plant required for tunnel operations would occupy considerable more space than any of the work above described, as it would not only include several dredges and scows but, also, equipment for driving and cutting off piles and for handling and sinking tunnel sections, which plans would occupy at least 600 ft. across the channel at one time. Any accident resulting in the loss of any part of the plant or section of the tunnel while it is being transported or sunk into position would add very much to the cost and also to the time required for completion, so that accidents might wipe out the saving which this method of construction is estimated to have over the shield-driven tunnel.

The Detroit River tunnel most nearly approaches in magnitude the work of the proposed tunnel, but the width and depth of that river are considerably less than of the Hudson River. Further, consideration must be given to the difference between the movement of traffic in the two rivers. In the Detroit River practically all of it is through traffic and the vessels are operating under their own power with full steerage headway, while in the Hudson River opposite Canal street the largest ocean-going vessels are moving either under reduced steerage headway or under the control of tugs, while the large volume of cross river traffic between the New York and the New Jersey shores offers more or less interference. Vessels operating under these conditions are much more difficult to control and require much more room than when operating under full headway without any considerable interference due to cross traffic. The present channel in the Hudson River is about 1,000 ft. in width, and located on the New York side of the river, so that the full distance of 3,200 ft. between pierhead lines is not available for the diversion of deep-draft vessels. However, work is about to begin toward widening this channel to a depth of 45 ft. for a width of 2,000 ft., so that this condition will be somewhat relieved. During the construction of the Detroit River tunnel it was possible to divert traffic much more readily than would be the case in the Hudson River.

The depth of water required by the War Department in the Hudson River necessitates dredging operations to a depth of approximately 90 ft. below mean high water in order to locate the top of the tunnel below the dredging plane. This will require a maximum cut in the river bed 63 ft. deep where the softness of the Hudson River silt makes the question of the slope at which the sides of the trench will stand problematical. There is a considerable difference of opinion as to the probable slopes which can be maintained and the uncertainty as to this question makes the estimate of cost of excavation unreliable. The engineering department has been unable to find any data which it considers would justify a decision in this matter and believes that before this method of construction is undertaken, investigations should be carried out upon which a definite conclusion could be reached. These investigations would require a considerable expenditure of money, for it would necessitate dredging operations on a large scale. With an experimental trench dredged, it would be possible to make observations over a period of time comparable with that which would be necessary for the preparation of the trench and for the sinking of the tunnel section, and in this way information would be obtained as to the probable volume of material to be excavated.



Typical Cross Section of Twin Cast Iron Tube Type of Construction for Hudson River Vehicular Tunnel.

A further consideration affecting the adoption of the trench method is that at the New York pierhead line a large mass of ledge rock will be encountered requiring from 50,000 to 80,000 cu. yd. of under water rock excavation, depending upon the depth of the tunnel.

The estimated cost of constructing the tunnel by this method indicates a possible saving, depending upon whether the assumed conditions are realized during the work such as the slope at which the Hudson River silt will stand and freedom from accidents, allowance for which would have to be made under the head of contingencies.

Building Operations in February.—Building activity has proceeded at a greater rate during the first two months of this year than during the first two months of 1919, according to statistics compiled by the F. W. Dodge Co. Conditions in the opening months of 1919 were very similar to those prevailing at present. Total contracts awarded from Jan. 1 to March 1, 1921, in the 25 Northeastern States of the country amounted to $212,437,000, compared with $152,784,000 for the first two months of 1918. The total contracts awarded in February, 1921, was slightly less than in the preceding month, but in view of the fact that February was shorter than January by three business days, the same rate of activity has been maintained during the two months. January contracts amounted to $111,648,000; February contracts, $100,789,000. Among the contracts awarded in February, residential building took the lead, representing 36 per cent of the total, or $36,294,000. Public works and utilities amounted to $18,-

[illegible] or 18 per cent of the tot[illegible] buildings, $17,070,000, or 17 per cent of the total; and industrial buildings, $9,037,000, or 9 per cent of the total. Contemplated new work was reported in February to the amount of $561,342,000. It should be explained that this includes $200,000,000 for the proposed bridge over the Hudson River, a project which will doubtless take a long time to mature. Nevertheless, even if this large project be omitted, the remainder of the contemplated work has been exceeded in only one month since last [illegible]

Creeping of Railroad Rails*

By JAMES E. HOWARD.

Engineer Physicist, Bureau of Safety, Interstate Commerce Commission.

The creeping of rails is recognized as a matter of importance and it is especially interesting to have the opinions of different observers brought together. From one point of view attention may be directed to the influence which creeping has on the fracture of rails.

Influence of Creeping on Fracture of Rails.—It is noticeable in the records that a considerable number of rails that have failed, have been in service for long periods, escaping other vicissitudes, but eventually succumbing by the development of lines of rupture across the bolt holes. Such failures display no appreciable enlargement of the holes in respect to ductile flow of the metal, although some abrasion may have taken place, perhaps accompanied with upsetting at the edges of the holes.

Drifting tests of adjacent bolt holes have shown the ability to endure enlargement in diameter without material, if any, impairment of ductility. This difference in behavior between metal at the bolt holes across which rupture has passed and neighboring holes calls for explanation. The destruction of ductility in steel is in general accomplished in one way, and without recourse to heat, in one way only. It is the result of repeated stresses of some kind.

Considered as a beam, it will be noted that longitudinal shearing strains reach their maximum in the vicinity of the bolt holes. Due to position, the web of the rail in this part of its length is most strained by longitudinal shearing forces. The interruption of the metal of the web by the presence of the bolt holes must be an intensifying factor. These forces, although not in themselves, or probably not, competent to cause rupture, may aid in promoting it in conjunction with other conditions which affect this part of the rail.

The more pronounced influence is believed to be the hammering action between the web of the rail and the shank of a track bolt which embrittles the metal at the sides of the bolt holes. When clearance is exhausted at the sides of the bolt holes by creeping of the rails or otherwise, this hammering takes place. Anchoring the rails by spiking the splice bars to the ties necessarily brings the web of the rail into contact with the shanks of the bolts, causing this hammering action.

The wave motions of the rails are interrupted at the joints, accentuating the functions of the splice bars, which reach a maximum degree of efficiency only in providing resistance against vertical shear between the rail ends. In other respects, the efficiency of the splice bars is doubtless somewhat less in degree.

The forward impulses given the rails which result in creeping probably bear a relation to the longitudinal strains in the base. The driving wheels of the engine tend to force the rail bodily backward while the wheels of the train have the opposite tendency to crowd the rails bodily forward. Just what takes place in different parts of the length of a rail with the wheels in different positions is a matter of much interest, and one difficult to ascertain accurately. The major movement of the rail is downward and has been measured from time to time. The horizontal components and how distributed with reference to a fixed point on the roadway as far as is known have not received attention.

Anti-Creeping Devices.—In respect to the magnitude of the forces with which an efficient anti-creeping device must contend, it might be said that it would depend on the rigidity of the device. The intensity of the forces which prevail in the longitudinal extension and compression of the rail are measured in thousands of pounds per square inch in the steel. However, these strains are exhausted within short distances. It is hardly conceivable that a close approach to the total arrest of longitudinal strains would be attempted or considered feasible to accomplish.

The place and manner of attachment of anti-creeping devices may be referred to. Possibly a distributed effort is the most satisfactory one and experience with anchors attached to the rail flanges by frictional contact has not developed serious disadvantages, considering the safety of the rail. Indentations or incisions in the flanges ultimately lead to rupture and present elements of danger. In a comparative sense the cushioning effect of a rail anchor against the side of a tie is a mild affair. The modulus of elasticity of soft wood, particularly when taken crosswise of the grain, is only a fraction of that of steel, therefore anchors which are used against the sides of the ties individually add only a limited longitudinal restraint when acting within short distances. Each train disturbs the ballast in some degree and the resistance of the tie itself thereby is reduced.

Ties would be expected to yield to individual impulses within the range of elastic longitudinal strains in the rail without interposing much resistance. Cumulative impulses would eventually move the tie, but the resistance of the tie against movement parallel to the track depends in a measure on the wheel load on the rail at the time. The firmness of the ballast below the rail is doubtless a factor in the case. It will be remembered, however, that longitudinal strains in both the base and the head of the rail are alternately tension and compression, hence impulses having to do with creeping, as far as the relations between longitudinal strains and advance of the rail are concerned, are the resultant effects of opposite strains.

Tests made by the writer in 1895 on the strains in rails in the track, including observations on the depression of the track on different kinds of ballast, showed the deepest depressions with cinder ballast, less depression on stone, and least on gravel. Frozen gravel ballast showed less depression than unfrozen gravel. These results were obtained on representative sections, in order to determine the relative depression of the rails laid on these three kinds of ballast.

It will be recognized that permanence of position of the rails in space depends largely on frictional resistance. Rails with or without anchors or anti-creeping devices remain nearly stationary by reason of the preponderance of frictional resistance between the rails and the ties, in excess of that between the rails and the wheels. The track partakes in a slight degree of the characteristics of a tread-mill. If the rails rested on anti-friction bearings the forward movement of an engine taken alone would be attended with a backward movement of the rails, accelerating forces, positive and negative, maintaining an equilibrium, the rate of speed of the engine in one direction and of the rails in the other depending on the laws of the engine in one direction and of the rails in the other depending on the laws of mathematics which govern accelerating forces. Of course, such hypothetical conditions could not prevail, but it will be recognized that the tendency of the motive power is to crowd the rails backward, while the wheels of the train tend to force them forward. The weight of the engines, the weight on the drivers, the distribution of these weights, and the effect of the wheels on the pilot truck, in a strict analytical sense, all appear to be of some importance.

A depression in the track which involves an almost equal depression of the adjacent roadbed necessarily draws the rails downward into the depressed area. The absence of tensile resistance in the ballast results in its separation, followed by recovery when the weight of the train is removed. The writer has found the area of depression under some conditions to be of measurable degree at a distance of 30 ft. from the engine.

In respect to the bodily movement of the rail, observations appear to be needed to judge of the relative displacements and the resiliencies which occur when a forward impulse is given the rail by the train and the elastic reaction which comes from the ties. Elastic recovery in compression is a factor of the case. In vertical recovery, ballast and ties act to the best advantage in respect to resilience. In a horizontal direction it is not clear what efficiency the ballast shows in recovery against slight longitudinal displacements or a succession of displacements, each of limited extent. Only in the case of frozen gravel ballast would horizontal resistance and resilience seem to be of marked degree.

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*[illegible] paper presented [illegible] J. A. L. Waddell [illegible] Society of C[illegible] An abstract of [illegible] the Nov. 17 [illegible] Engineering and Contracting. Notes from its discussion were printed in the Jan. 19 issue.

Rail Laying With Locomotive Cranes

For several years it has been the practice [illegible] Valley R. R. to lay all rail with locomotive cranes. This method, developed by the maintenance of way forces, has proved a decided success both from a labor standpoint and also from the standpoint of transportation delays incident to rail laying. The Lehigh Valley method was described in our Jan. 19 issue. Further particulars are given by Mr. W. C. Barrett, Trainmaster, Lehigh Valley R. R., in the March Bulletin of the American Railway Engineering Association, from which the notes following are taken.

By the use of locomotive cranes several track miles of rail can be laid in one day and the total delay to trains will be less than if several days were used for the same work and all trains stopped and more or less delayed each day. With the heavy sections of rail in use at the present time, the labor required to handle it by hand is almost prohibitive. The locomotive crane does the heavy lifting and thereby relieves the laborers for other lighter work.

Method of Placing New Rail.

A typical outline of the organization used for rail laying with a locomotive crane is given below:

1 Supervisor of track—in general charge
1 Foreman—20 men—pulling spikes.
1 Foreman—10 men—adzing, driving tie plugs and placing tie plates.
1 Foreman 6 men—throwing out old rail and laying new rail with crane.
2 Foremen—15 men—gaging and driving quarter spikes.
3 Foremen—30 men—putting on joint bars.
3 Foremen—30 men—driving spikes.
2 Foremen—15 men—putting on anti-creepers and bonding where necessary.
1 Foreman—7 men—drilling for bond wires with pneumatic drills.
1 Signal supervisor or assistant in charge of signals and bonding
1 Signal maintainer and one helper renewing signal wires and connections.
1 Foreman—4 Signalmen—bonding.
Total—18 Foremen—138 men.

This organization and number of men will keep the locomotive crane working practically continuously, and will enable it to lay from 100 to 150 rails per hour. The crane can be worked with any number of men from 10 up, as it requires but six besides the operator to place the new rail. Very good progress can be made with 50 men, and more rail can be laid with this number of men, using the locomotive crane, than can be laid by hand with the same force.

It is desirable to have two cranes laying when there is any number of miles of track to lay, having two organizations and each crane and organization laying one rail—the second crane working far enough behind the first so as not to interfere with each other. When only one crane is used, one rail is laid and the crane backs up to the beginning point and then lays the second rail in the same way as the first. The work of placing the joint bars, full spiking, lining, placing anti-creepers, bonding, etc., is done behind the crane. The organization outlined will keep this work up so closely that in from 15 to 30 minutes after the crane has finished laying the rail, the track is ready for service. On a busy single track, main passenger line, of the Lehigh Valley, two cranes laid 565 rails in two hours and 30 minutes, from the time the track was broken until it was connected, and the automatic signals were in service again.

A recent development has been the use of pneumatic tie tampers to operate pneumatic drilling machines for bonding. One tie tamper operates four machines and one outfit will usually keep up with two locomotive cranes. However, where the cranes have a good opportunity to lay rapidly, it is desirable to have two drilling outfits, so as to avoid the possibility of delay when closing up at the end of the job. It has been found possible to operate the air compressor continuously and at the same time move the car under its own power from joint to joint, thereby eliminating the necessity of pushing the car by hand.

By the use of the locomotive crane for laying and the pneumatic drilling machine for bonding, the heavy work is taken off the men, and rail laying is no longer the hard task it formerly was. The men like the new scheme and it means better working conditions, better satisfied men, and at the same time greater efficiency and decreased cost.

Co-operative Investigations on Tunnel Ventilation

The United States Bureau of Mines and the New York and New Jersey State Bridge and Tunnel Commissions have entered into an agreement to conduct co-operative investigations in connection with the ventilation of the projected Hudson River vehicular tunnel. The co-operative investigations have to do with the best method of supplying the requisite amount of fresh air to remove the poisonous products of combustion from motor vehicles.

Last November, under a similar co-operative agreement, the Bureau of Mines made a report to the Commissions relating to the amount and composition of exhaust gases from motor vehicles and the necessary dilution of such gases with fresh air to render it absolutely harmless. The answer to the first problem was obtained by making road tests on 101 automobiles and trucks at the bureau's experiment station at Pittsburgh, Pa. These tests were made under the direction of A. C. Fieldner, supervising chemist. The answer to the second problem was obtained by a series of comprehensive tests on a large number of students in the physiological laboratory at Yale University, New Haven, Conn., conducted by Dr. Yandell Henderson, consulting physiologist of the Bureau of Mines. Dr. Henderson found that no noticeable symptoms of discomfort appeared after one hour's exposure to concentrations of carbon monoxide in air not exceeding four parts in 10,000.

Having found the answers to these two problems, there yet remain the important question of the best method for moving the required quantity of air through the tunnel and finally the checking up all the results of these various investigations by building a model of the proposed tunnel in which final observations of the efficiency of the proposed system of ventilation can be made. This is the purpose of the investigations now to be conducted by the bureau in cooperation with the Tunnel Commissions.

Ascertaining the best methods of supplying the requisite amount of fresh air depends largely on the determinations of certain factors with reference to the flow of air in ducts and bends, such as will be used in the tunnel. The investigation on this problem is to be carried on at the University of Illinois, Urbana, Ill., where the Bureau of Mines has its Central District Experiment Station. The investigation will be directed by Prof. A. C. Willard, head of the Department of Mechanical Engineering, who is one of the leading authorities on heating and ventilation in this country. Prof. Willard is also a consulting engineer of the United States Bureau of Mines in connection with the study of ventilating problems in mining practice. An experimental duct 300 ft. long, similar to the proposed ducts in the tunnel, is being constructed at Urbana. The Bureau of Mines is installing special 300-HP. motors and fans for making these experiments. The data obtained will be of fundamental importance, not merely to the ventilation of the Hudson River tunnel, but particularly in the metal-mining industry where air is handled at high velocities. The determination of friction of the flow of air in concrete ducts is urgently needed in view of the growing use of concrete construction in modern metal mining.

The final check on the solution of the three previous problems will be obtained in an experimental tunnel that is now being constructed in the Experimental Mine of the Bureau of Mines, at Bruceton, Pa., just outside of Pittsburgh. An oval-shaped tunnel having similar construction of ducts to those proposed in the Hudson River tunnel and an axial length of 400 ft. is being constructed underground. The cross-section is large enough to run a single line of automobiles through this tunnel with the usual space. Studies will be made with respect to the following features:

(a) The diffusion of exhaust gases in the cross-section of the tunnel.

(b) Temperature conditions as affected by the operation of internal-combustion motors.

(c) Physiological effects of temperature, exhaust gases, and smoke under operating conditions.

(d) Final check on all previous investigations.

The investigation at Pittsburgh is under the direction of A. C. Fieldner, supervising chemist, and J. W. Paul, mining engineer. George S. Rice, chief mining engineer, and Prof. A. C. Willard, consulting ventilating engineer, are consultants on the ventilation experiments. Dr. R. R. Sayers, chief surgeon of the Bureau of Mines, and Dr. Yandell Henderson, consulting physiologist, are carrying on the physiological studies in the experimental tunnel.

A New Outfit for Welding Rail Bonds

A new arc rail bond welder brought out the past year by the Wilson Welder & Metals Co., New York, is illustrated. As shown in the photograph, the unit is furnished mounted complete, ready to go to work, as a portable unit with flanged wheels suitable for standard gage track unless otherwise specified. It has a fish pole with proper attachments for connecting to the overhead line wires.

The unit is so constructed that it is easily handled by two men. The dynamotor and starting box weigh about 390 lb. and in clearing the track are first lifted from the machine and placed upon the ground at the side of the track. The truck and automatic control panel, weighing about 275 lb., are then readily lifted from the track.

The unit is made only in one arc capacity with motors for different voltages. The units for normal line voltage of 250 volts, D. C. for mine work will take care of a line voltage range of from 175 to 350 volts. The unit for normal line voltage of 500 volts D. C. for mine, trolley and third rail work will take care of a line voltage range of from 350 to 700 volts. Both units will weld satisfactorily at the lower limit of voltage and will automatically take care of any sudden surge up to the higher limit of voltage.

Wilson Plastic Arc Rail Bond Welder.

Great care has been taken in the magnetic design, so that all troubles caused by sudden surges of high voltage are avoided. A flash over caused by heavy surge is next to impossible. The rail bond welder is of the enclosed type, so that the windings cannot be damaged by anything dropping in the machine; at the same time water from a sudden rainstorm will not get into the windings.

A modified standard Wilson controlling panel is used in conjunction with the dynamotor and will keep the current constant at any predetermined current it is set for. This modified panel is known as the type K-5; it is compact and of light weight and consists of the following parts mounted on Ebonite non-fragile board: 1 main switch, two pole; 1 voltage switch, single pole; 1 combined volt ammeter, range 0-75 volts and 0-300 amps; 1 carbon pile; 1 solenoid; 1 pressure spring; 1 dashpot.

Welding range, 75-175 amperes. Maximum capacity continuous welding, 150 amperes at 37.5 volts at panel terminals. A standard C. & H. starting box with no voltage release is furnished.

The unit is light in weight, compatible with high efficiency and continuous output. It is not designed to run only a few minutes at a time, for its temperature rise is the same as the standard Wilson machine, and it will therefore work continuously at full rated load.

Cost of Operating 6-Ton Truck in Moving Coal

The Youghiogheny Coal Co., the largest retail coal dealer in the Pittsburgh district, moves over 60,000 tons of coal monthly by motor truck. The company has a fleet of 15 6-ton trucks. Some interesting figures on the operation of these trucks are given in The Coal Age, from which the note following is taken.

It has been found that these 6-ton trucks will cover 2.15 miles on a gallon of gasoline and that an equal measure of lubrication oil furnishes sufficient lubricant to the motor for 130 miles of travel. In computing truck-operation costs, nothing is overlooked by the Youghiogheny officials. Table I shows the costs of operation of a single 6-ton truck for one year.

TABLE I—COST OF OPERATING COAL TRUCK FOR ONE YEAR

Wages	$4,064.46	Tires	$ 164.35
Depreciation	1,365.45	Repairs and supplies	692.28
Gasoline	1,196.11	License	25.00
Lubricants	119.83	Superintendence	179.38
Garage	700.20	Workmen's compensation	59.78
Insurance	369.57		
Total expenses			$8,936.41

TABLE II—AVERAGE YEARLY RECORD OF MACHINES IN SERVICE.

Total hours	2,529
Total miles	9,103
Tons hauled	17,581
Total expenses	$8,936.41
Cost of operating one hour	$3.53
Cost of hauling one ton one mile	$0.17
Average tons to a load	5.87

In figuring the cost of hauling one ton one mile the mileage figured is that made by the truck in running under load. The wages may appear high but this expenditure is for two men, for to each truck a driver and a helper are assigned. The company owns its own garage, but this expense is charged up to the trucks as if space of equal area were being rented. This illustrates how closely operating costs are calculated.

This expense, shown as $3.53 in Table II, is rather high because a company using trucks from its tipple over a comparatively long haul probably would not have need of two men on the machine.

Long-Lived Track and Wood Preservation

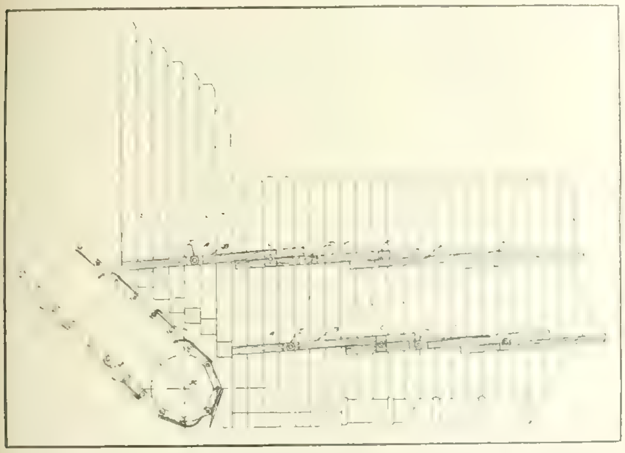
There has been some disagreement among track engineers on the question of the value and the need for preservative treatment of wood ties when laid in conjunction with well-paved track. Not a little light is thrown on the subject through the article by W. L. Whitlock in the issue of this paper for Jan. 22, wherein the statement is made that treated hemlock ties were found to be in a good state of preservation after 22 years of service in the tracks of the Denver Tramway.

Hemlock ties, untreated, have an average life of five years in open track, according to estimates on tie life given in H. F. Weiss' book on timber preservation. On this basis the results reported for the Denver installation indicate that the treatment has increased the life of the tie more than four times the estimated untreated life. Mr. Weiss gives the estimated life of treated hemlock ties in open track as 15 years. Hence, it may reasonably be argued that the track pavement under which the ties in question have been in service, by keeping the ties in a fixed state of moisture content, has added seven years to the estimated treated life of hemlock ties.

Mr. Whitlock also states his belief that the good waterproof pavement, which was wisely installed when the tracks were built, proved to be a prominent factor in preserving the other parts of the track structure and accounts for the remarkably small amount of deterioration found in all details of the track. This statement fits in with the observations of the editors of this paper to the effect that good pavements are essential to good tracks and that when the water is kept out of the substructure the pavement acts as a real track life preserver. "Keep the water out" has become an axiom in the track engineer's manual.—Editorial in Electric Railway Journal.

Method of Sheeting Trench in Running Sand

The illustration shows a method of putting in cribbing after a ditching machine trenching in caving and running sand. The ditch ran from 8 ft. to 14 ft. in depth. The drawing shows the angle at which the stretchers were run. After stretcher "G" was in place, "F" was put on it, and a jack placed at "D" and another at "E." When "B" was put in position, the jacks "I" and "C" also were put in, and jack "D" removed.



Sketch Showing Method of Sheeting After Ditching Machine in Running Sand.

The length of stretchers used was 8 ft., and they were lapped over each other about 3 ft. The sheathing followed the digger "K" as closely as possible, even up the slopes as shown at 1, 2, 3, 4-7. The lower stretchers were placed in the same manner as the top stretchers. The arrangement was devised by W. E. Donner of Houston, Tex. By means of it an average of 300 ft. of 12-in. tile was laid per 10-hour day.

Occupations of Technical Graduates.—The following table, compiled from the "Register of Former Students" of Massachusetts Institute of Technology and printed in the February Tech. Engineering News, gives an approximate idea of the graduates of the Institute who are not working within the scope of their professional course:

Course.	Per cent of graduates in their course.
I —Civil Engineering	[illegible]
II —Mechanical Engineering	[illegible]
III —Mining Engineering	[illegible]
IV —Architecture	[illegible]
V —Chemistry	[illegible]
VI —Electrical Engineering	[illegible]
VII —Biology and Public Health	80
VIII—Physics	[illegible]
IX —General Science or General Engineering	[illegible]
X —Chemical Engineering	[illegible]
XI —Sanitary Engineering	[illegible]
XII —Geology	[illegible]
XIII—Naval Architecture	[illegible]
XIV —Electrochemical Engineering	[illegible]
XV —Engineering Administration	[illegible]

Most of those who are not following their professional course have forsaken engineering and science, but some have remained in a branch of engineering or science quite different from that part of their preparation. In compiling the table, men at work in branches closely allied to their course have been considered as at work in it. Commenting on the facts brought out in the table the Tech. Engineering News says: Course VIII men show the greatest tendency to leave their professional course, largely because they may enter various branches of engineering with comparative ease. Then come Course IX men for the same reason. Course XI men show the same percentage of changes, many of these men going into straight "Civil" work. The large variety of changes entirely away from engineering and allied occupations come from the men who have taken the older and more popular courses, namely, Civil, Mechanical, Electrical Engineering and Chemistry. Geologists stick to their profession with the greatest tenacity. There are M. E.'s in the wholesale grocery business, piano manufacture and building construction; farming and general contracting have attracted a large number. Civil Engineers are practicing electrical and mechanical work, are in the clothing and laundry business, are found amongst the clergy, and some are certified public accountants. Banking, insurance, and brokerage have attracted electrical men more than others. One architect has become a genealogist, chemists have become physicians, and General Engineers have become dentists. Many patent lawyers have graduated from the course in Chemical Engineering; forestry is another profession taken up by the Chemical Engineers.

Average Street Railway Fare Increased Only 48% Since 1913

The average rates of street car fare in effect from 1913 to January, 1921, in cities of the United States of 50,000 population or more, are shown in the accompanying tabulation taken from the February Aera. The figures, which were compiled by Prof. Albert S. Richey, consulting electric railway engineer, show the average rates in effect during the past eight years in all cities in the United States having 50,000 or more population, with the exception of New York City, weighted according to population. Where charges are made for transfers and reduced rate tickets sold, these facts have been taken into consideration in making the calculations. From the table it will be noted that the average rate of fare for this group of cities has increased from 4.8425 ct. in 1913 to 7.1762 ct. in January, 1921, or approximately 48 per cent. A glance at the figures also shows that the increase from month to month has been gradual with no marked rises. In June, 1918, the average fare touched 5 ct. and it was not until August, 1919, that it passed the 6 ct. mark, and November last that it reached 7 ct. Professor Richey's table in full follows:

AVERAGE STREET RAILWAY FARE WEIGHTED BY POPULATION.

	Cents.		Cents.
1913	4.8425	April, 1919	5.5483
Sept., 1914	4.8483	May, 1919	5.5964
Jan., 1917	4.8474	June, 1919	5.6431
March, 1917	4.8496	July, 1919	5.7902
April, 1917	4.8507	Aug., 1919	6.0593
July, 1917	4.8722	Sept., 1919	6.1123
Oct., 1917	4.8978	Oct., 1919	6.1471
Dec., 1917	4.9096	Nov., 1919	6.2920
Jan., 1918	4.9244	Dec., 1919	6.2475
Feb., 1918	4.9259	Jan., 1920	6.2893
March, 1918	4.9326	Feb., 1920	6.2912
April, 1918	4.9477	March, 1920	6.3048
May, 1918	4.9792	April, 1920	6.3505
June, 1918	5.0625	May, 1920	6.3884
July, 1918	5.0870	June, 1920	6.4866
Aug., 1918	5.2047	July, 1920	6.6820
Sept., 1918	5.2412	Aug., 1920	6.8511
Oct., 1918	5.4238	Sept., 1920	6.9033
Nov., 1918	5.4368	Oct., 1920	6.9441
Dec., 1918	5.5383	Nov., 1920	7.1167
Jan., 1919	5.5675	Dec., 1920	7.1420
Feb., 1919	5.5703	Jan., 1921	7.1762
March, 1919	5.5731		

Illinois Leads Nation in Electric Railways.—Illinois ranks first in the amount of money and development of its electric utilities, second in wealth and railway mileage, second in electric railway trackage and investment, second in telephone investment and development and third in manufactures in the 48 states of the Union, according to the annual reports of the Illinois State Electric Association, Illinois Gas Association and Illinois Electric Railway Association. In 1906 the reports show the investment in electricity, gas, electric railways and telephones in Illinois was but $375,000,000, or about $75 an inhabitant. On Dec. 31, 1920, the investment hal reached more than $1,300,000, or $192.20 per man, woman and child in the state. The demand for service has increased at such rapid rate that $125,000,000 a year is needed from investors for additional plants and equipment, the reports declare, while the number of employes is in excess of 180,000. Owners of securities of the utilities number close to 450,000.

Subways for Capital City of Japan.—Plans for 30 miles of subway lines to be built in Tokio, capital city of Japan, are now under consideration, according to a press dispatch. Ever since the plan for the underground lines as a means of relieving the badly congested traffic of Tokio was suggested in 1918, there has been skepticism because of the fact that Tokio is built on ground that was once part of the sea, or "made ground." The new engineering company, agents for the Tokio Underground Railways Co., Ltd., claims to have made tests and announces that there is no doubt of the ability of the land to stand the construction of the subway. The company received its charter in 1918 from the government. It has recently voted to increase its capital stock from Y10,000,000 ($5,000,000) to Y80,000,000 ($40,000,000). If the plans as submitted are carried out Tokio will have the first underground railway line ever built in the Orient. While the company's plans are still in the formation stage, it has gone as far as to establish headquarters in the Kaijo Bldg., Tokio, and arrange for calling into consultation prominent engineering men from France and America.

Breaking Up Old Masonry with Quicklime.—According to a bulletin of the National Lime Association the expansive force developed by slaking quicklime affords an easy way of breaking up an old stone wall or other masonry or knocking out a brick pier. The suggested method of using this quicklime is as follows: Drill a good-sized hole in the wall—making this bottle shaped with as small an opening as possible. Put in quicklime until this hole is almost full and make a tight-fitting wooden plug that can be driven firmly into the opening. Quickly pour in enough water to slake the lime and drive home the plug. The expansion of the lime as it slakes will exert a tremendous pressure that will easily break up any ordinary piece of masonry.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

The L. J. Smith Construction Co. will finish tracklaying on the [illegible] & Northern R. R. in Texas in a few days. They shipped another steam shovel and a number of cars to their bridge-filling job on the White River branch of the Missouri Pacific R. R. in southwestern Missouri and northwestern Arkansas.

The Board of Supervisors of the Little River Drainage District of Cape Girardeau, Mo., has let the contract for the Sale Creek diversion channel and for clearing out of Castor River from Zeta to the head of Ditch No. 39 in Stoddard County to W. E. Callahan Construction Co. of Dallas, Tex., for $195,075. One bid was cheaper than the Dallas firm, but it was based on work by one machine. The Callahan Company, besides getting the contract from the Little River commissioners, has a $2,000,000 contract for ditching in Butler County for the Interriver Drainage District.

Johnston, Austin & Mautz of Benton, Ill., are low bidders on 129,000 yards of Illinois state road work; also 660 yards of small culvert (concrete) work. They expect to open an office in Ashley, Ill., when contract has been signed. James Austin will be in charge.

Plans are to be made immediately for a new viaduct over the Santa Fe tracks at 26th street, in Kansas City, Kans., according to information given to J. L. Beggs, street commissioner, by H. L. Wagner, chief engineer for the eastern lines of the Santa Fe. The new viaduct will replace an outworn wooden structure. The 26th street viaduct is part of an important thoroughfare from the north side of Kansas City, Kan., to the Santa Fe station in Argentine.

George Peterson, another one of the good old-time contractors, has passed away. Peterson died at the home of his son, W. J., in Omaha, at the age of 69 years after a brief illness. Four sons, Martin, W. J., Edward and Charles Peterson, survive.

Contract for designing the 14-story Tristate Hotel for Memphis was let to Barnett, Haynes & Barnett, St. Louis architects. The building is to cost $1,500,000 and will have 400 guest rooms.

Harrington Bros. are back in the contracting game with both feet. The boys have been quiet for the past year or so, but went to Springfield at the big state road letting on Feb. 19 and copped off a 190,000 yards of grading, Route 25, Section 3A, at Effingham, Ill.

More than $360,000 worth of securities of the Decatur Water Supply Co., organized with a capital of $1,000,000 to assist in financing the impounding of an adequate water supply for the city, were sold to the Decatur citizens the first week in March. The dam now under construction is financed by a bond issue. The money raised by the water supply company will be used to buy the 4,000 acres of land that will be flooded.

Buis & Olson, St. Joseph, Mo., are low bidders on grading a couple of sections of the new Illinois state roads.

Approximately $500,000 will be spent on improvements by the East St. Louis & Interurban Water Co. C. M. Horner, superintendent of the company, said on his return from the east, where he has been inspecting water plants. Among the improvements will be a new reservoir and a new outlet sewer to the river at the high service station, N and Front streets, East St. Louis. Belleville, Venice, Brooklyn and Madison, as well as East St. Louis are served from the plant.

T. L. Aldridge & Co., Wolf Lake, Ill., secured a piece of grading in the new Illinois state roads.

Ira J. Printy is finishing his state road job in southern Illinois. Expects to move on to another in central Illinois as soon as through.

M. L. Windham is repairing two steam shovels at Centralia, Ill., getting them ready for spring.

J. H. McFarlin is laying some industrial tracks in Springfield, Ill. Bought some rails here last week.

Springfield, Ill., looked like a contractors' convention or picnic on Feb. 18 when bids were opened for constructing 125 miles of hard roads in the state this year. Over 400 bids were submitted. The compilation of figures by the State Department shows the following low bidders on the various sections throughout the state: Jackson County, Section 1, Schmidt Bros.' Constr. Co., Chicago, or Hamilton Construction Co., Carbondale; Perry County, Sections 5 and 6, H. Pfitzmeyer, Jr., Terre Haute, Ind.; Livingston County, Section 8, Fred Lorenz, Oak Glenn; Livingston County, Section 9, Andrew Ward, Oak Glenn; Livingston County, Section 10, Hedges Construction Co., Chicago; Kane County, Sections 8, 9 and 10, McCall Construction Co., Chicago; Henry County, Section 2, Schmidt Bros.' Construction Co.; Henry County, Section 4, J. J. Dunnegan, Shenandoah, Ia.; Knox-Warren Counties, Section 1, Schmidt Bros.' Construction Co.; Knox County, Sections 1 and 2, J. J. Dunnegan; Champaign County, Sections 1, 2 and 3, William Menley, Frankfort, Ind.; Macon County, Sections 13 and 14, Hedges Construction Co.; St. Clair and Clinton Counties, Sections 2 and 3, Frazer-Davis Co., St. Louis; Washington County, Sections 9 and 10, Cameron-Joyce Co., Keokuk, Ia.; Kankakee County, Shidler Construction Co., Kankakee; Effingham County, Section 1, Mantz & Orren, St. Elmo.

E. A. Michall has eight teams, wheelers and fresno outfit idle at Geneseo, Ill.

W. A. Gierke has finished his work at Roodhouse, Ill. Looking for a job suitable for a 10-team outfit.

L. I. Viall is about through with his steam shovel work at Sleeper, Mo. Has two shovels that he can place on work immediately. Sleeper, Mo., or 3936 Euclid Ave., Kansas City, Mo., will catch him.

The city of Moberly, Mo., is receiving bids for construction of a new reservoir.

F. E. Houck, secretary-treasurer of the Fred R. Jones Co., Chicago, was in town the other day looking over this part of the country. Nothing new.

Contractors, when in want of labor or work for their outfits get in touch with the Koenig Labor Agencies, 612 Walnut St., St. Louis, or 501 Delaware St., Kansas City, Mo.

Gov. Len Small of Illinois on March 5 instructed Col. C. R. Miller, director of public works and buildings, to reject all road bids received on Feb. 18.

Mike Walsh was awarded contract for the excavation and foundation work for the new city hall addition in Kansas City, Mo. Walsh's bid was the lowest of eight bids and $400 under the city engineer's estimate.

B. F. Brooks Construction Co., Eastland, Tex., have a 20-team machine and fresno outfit idle.

Personals

W. N. Grambling, formerly city engineer of Brunswick, Ga., has been elected city manager.

Frank Aydelotte, American secretary to the Rhodes Scholarship trustees and professor of English at Massachusetts Institute of Technology, has been chosen president of Swarthmore College, Swarthmore, Pa. He succeeds Dr. Joseph Swain, who retires in June.

C. T. Jackson, heretofore district engineer Chicago, Milwaukee & St. Paul Ry., has been appointed principal assistant engineer. He will be located in Chicago and will handle such matters as may be assigned by the chief engineer. The two offices of district engineer on the Southern District have been consolidated.

Capt. Charles F. Healey, a member of the staff of the director-general of transportation of the A. E. F., has been appointed assistant city engineer of Chicago by City Engineer Alexander Murdoch. Victor S. Patterson, the present assistant engineer, will return to his old position of chief efficiency engineer in the office of the City Controller.

G. W. Abbott, division engineer, Boston Division, Boston & Albany R. R., has been appointed principal assistant engineer, with headquarters at South Station, Boston, succeeding E. S. Draper, deceased. W. B. Knight, division engineer, Albany Division, has been transferred to Boston Division, with headquarters at South Station, Boston, succeeding Mr. Abbott. E. K. Mentzer, supervisor of track, sub-division 1, has been appointed division engineer, Albany Division, with headquarters at Springfield, succeeding Mr. Knight. F. A. Jones, office engineer, South Station, Boston, has been appointed supervisor of track, sub-division 1, with headquarters at South Station, Boston, succeeding Mr. Mentzer. E. G. Hartford, assistant engineer, has been appointed office engineer, with headquarters at South Station, Boston, succeeding Mr. Jones.

Industrial Notes

Henry Hoeltge, until recently western advertising manager for The Plumbers' Trade Journal, Steam and Hot Water Fitters' Review, has been appointed advertising manager of The Central Foundry Co., 90 West St., New York. Mr. Hoeltge is an old Central Foundry man, having rounded out several years with this company prior to entering the army back in 1917.

A. M. Castle & Co. of Washington, Seattle, Wash., dealers in steel and hardware, have recently purchased a large portion of the real estate and buildings owned by the Skinner & Eddy Shipbuilding Corporation at Seattle, Wash. The cost value of the property was approximately $625,000. The property thus acquired will permit the A. M. Castle & Co. of Washington to carry out its plans for expansion into carrying a larger stock of materials, including all sizes and shapes of structural steel.

The Conveyors Corporation of America, formerly The American Steam Conveyor Corporation, Chicago, announces that the Power Equipment Co., 131 State St., Boston, has been appointed as New England representative for the sale of its American trolley carrier, monorail equipment for handling coal, ashes, sand, gravel and other loose bulky materials. Colwell & McMullin, 79 Milk St., Boston, are the New England representatives for the company's American steam ash conveyor.

The Plymouth Cordage Co., of Plymouth, Mass., has undertaken an unusual and interesting activity in connection with the celebration to be held next summer at Plymouth to celebrate the 300th anniversary of the establishment of the Plymouth colony. Thousands of new people will visit the famous watering place during the summer months while many other thousands while interested in the activities there, will be unable to attend. The Plymouth Cordage Co. is preparing to welcome those who come and to furnish those who cannot come with interesting information as to the activities. To do this properly, the Plymouth Cordage Hospitality Club has been formed. It is not a commercial organization. A new brick clubhouse is being built. Information Bureaus will be established and special recreational facilities have been decided upon. All this has been done for those who come. But the club officers realize that but very few of the people who are interested in the celebration will be able to attend and for these members who cannot come they are preparing a series of souvenir booklets. The first of this series is now ready for distribution. Furthermore, the Information Bureau of the Plymouth Cordage Hospitality Club is always open to all of its members whether they are coming to Plymouth or not. This Bureau will give any information required about New England—its motor routes, train schedules, every activity in which the average vacationist is interested. There are no dues nor obligations connected with this club. Everything is free. It is founded in the spirit of good-fellowship. The very unusual object and activities of this club have caused thousands to become members.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Should the Public Regulate Rents?

In many cities rents have risen so greatly that public regulation of rents is not only being discussed but steps are actually being taken to place city real estate in the category of a public utility subject to the control of a rate-regulating body. For example, the city of Los Angeles recently passed an ordinance limiting annual rents to 11 per cent gross on the cost of the land and building. New York State has a new law controlling rentals and the Illinois Legislature is considering a bill of similar nature.

The U. S. Supreme Court will doubtless declare void any law that limits rents to a fixed per cent upon the cost of land, for the 14th amendment prohibits the confiscation of property value. Moreover, what is the "cost" of land?

If it is its "original cost," then it is nothing. If it is the price paid by the last purchaser, it can change in the time that it takes to sign a deed.

Henry George advocated the confiscation of all land values by the Government, his device for effecting the confiscation being a tax equal to the land rental. But the present advocates of public control of land rentals stop short of so extreme a measure, and in doing so show less knowledge of economic principles than even Henry George showed. They would base land rentals upon cost, but they fail to show how the cost of land can be regulated.

As for the rental of buildings alone, it would not be difficult to base a rental upon the cost of the building, for the original cost would be estimated closely even where no record of the cost exists. But here we confront an economic difficulty of another sort. A building erected in 1920 has cost twice as much as a building of the same size and type erected in 1914. Shall the tenants of the 1920 building be required to pay twice as much rental as the tenants of the 1914 building? That is what the cost theory would lead to. Consequently nearly all tenants would seek the older buildings. Who would decide as to the conflicting claims among tenants for leaseholds? Would not the public rental commission be obliged either to resort to casting of lots or else show favoritism? And what of the investors in buildings? Would they not also seek to buy old buildings and refrain from erecting new ones, knowing that tenants would prefer the old buildings?

Among public utility rate experts it has long been a moot question as to how the cost theory of rate regulation could be successfully applied to two parallel railways whose cost of construction had differed considerably. If freight rates were made high for one and low for the other, as they would have to be if their respective costs differed, then the low cost road would secure nearly all the traffic and the high cost road would be ruined. If freight rates were made the same for both, and based on the cost of the high cost road, then the low cost road would have freight rates not based on its cost, thus upsetting the cost theory of regulation, to say nothing of the enormous profits that the low cost road would be allowed to secure. If the cost theory of price regulation encounters great objections even in the case of two competing railways, consider the much greater difficulties that beset the application of a cost theory applied to rentals of numerous buildings.

Probably the greatest of all objections to any cost theory of price regulation is the premium that it puts upon inefficiency and the brake that it applies to the wheels of progress. To be held down to a fixed annual percentage of the cost of property is tantamount to being told that economy of location or design shall receive no reward. Under such a scheme the "skyscraper" would probably not have been invented for many years after it was invented. Indeed, it might yet be unknown. Under such a scheme the reinforced concrete building might not have been invented, for what object would there have been in designing a fireproof building lower in cost than one of brick?

Engineers and architects exercise their ingenuity for the purpose of reducing costs to their clients, in order that those clients may increase their profits. But if the public were to base rentals upon costs, engineers and architects would have no adequate incentive to reduce building costs.

The cost theory of price regulation is economically unsound, whether applied to public utilities or to buildings. Its application to railways and other public utilities for the past 15 years is mainly responsible for the steadily decrease in progress in those fields. Shall a theory that has shown such poor economic results when applied to railways, traction lines, gas plants, etc., be applied to city real estate? And if applied to city real estate shall it not be extended to include country real estate—farms?

The advocates of rental regulation in cities have apparently no knowledge at all of what the cost theory of price regulation logically leads to. They feel the pinch of rising rents and cry to legislative bodies for relief. The very persons whose wages have been doubled in six years denounce their landlords as "rent hogs" because they also seek a doubling of their income. With equal logic the landlords might call their tenants "wage hogs." It is the old story of microscopic vision for one's own fortune and myopic vision for the fortune of others.

Secretary Wallace Advocates New Price Level 70% Above Old Level

Secretary of Agriculture Wallace declares his belief in the wisdom of maintaining a price level 70 per cent above the prewar level. He says:

> We cannot hope to reach normal conditions until we arrive on a price level which will be fair to all our people and all products. Farm products must increase in price and other products must come down until the normal relation between the two has been restored. This talk of bringing prices, whether farm prices or other prices, back to the pre-war normal is morally wrong and economically impossible.
>
> We incurred a heavy national debt on the inflated prices. If we could force all prices back to the pre-war normal—which we cannot—it would be equivalent to just about doubling that debt.
>
> We can pay off our debts much easier if we maintain a price level more nearly that at which the debts were incurred. Of course, the excessively high prices which prevailed during the war cannot continue, but if we should try to bring about a level, say, 70 per cent above the pre-war level everybody would be better off.

During our Civil War our per capita currency was increased 50 per cent, rising from $14 per capita in 1861 to $20.60 in 1865. It fell to $19 in 1866, and to $18.30 in 1867—a drop of 10 per cent in two years. It then remained at practically that level till 1874, when it began to fall slowly, reaching a level of $15.30 in 1878. But three years later it was up to $21.70, from which level it rose steadily thereafter.

In January of 1921 our per capita currency in circulation was $59.10 as compared with $34.35 in July, 1914, or a 72 per cent increase. It was probably this percentage increase in currency that led Secretary Wallace to suggest a new price level 70 per cent above the prewar level. He is entirely right in arguing that our national debt would virtually be enormously increased were we to return to the prewar level of prices. This argument has been used with effect after every great war of modern times. It was this argument that prevented the early retirement of greenback currency after our Civil War.

Changes in Commodity Prices

We give in this issue the wholesale price indexes of commodities by months for the past seven years. It will be seen that the average of all commodities was 167 for February, as compared with an average of 100 for the entire year of 1913. It should be noted that farm and food products have declined more than any other class of commodities. The decline in farm products has been so great that we may look for a rebound from the low levels that now exist. In seeking reasons for the differences in relative price declines, it is noteworthy that the declines have been greatest for those classes of commodities that are produced by the greatest number of individuals or companies. In such cases not only is the competition apt to be of a cut-throat nature, but the producers usually live from hand to mouth, being dependent largely upon banking credit. This is particularly the case with farmers. Hence the prices of farm products are apt to swing violently up or down, entirely apart from fluctuations in crop yields.

Of special interest to the economist should be the difference in price variations of copper and aluminum. Copper has always been very sensitive to business conditions, whereas aluminum has been far less sensitive. Copper is produced by a great number of mining companies. Aluminum is produced by very few companies. Such facts indicate that excessive competition among financially weak companies is one of the great causes of rapid and wide changes in the prices of their products.

It will be seen that the price index for building materials was 223 for February, as compared with 341 for last May, a decline of 33 per cent from the peak. Building materials will probably recede still more in price, possibly to a level of 170. On the other hand, many other commodities will probably rise, for, in the long run, the tendency of each class of commodities is to follow the general price level.

The weekly price indexes that are published by the two great mercantile agencies (Dun and Bradstreet) indicate a decided slackening in the general decline during March. This was to be expected, for the general level of commodity prices (167) is now on a parity with the per capita increase in currency in circulation. There will be a temporary fall of average prices below this level, because the velocity of money turnover, which has been declining very rapidly for nearly a year, will decline below its normal before it swings back to normal; but, judging from past experience, further decline in the rate of money turnover will not be much below the present rate.

A Formula for Predicting Average Wage Rates

In our issue of April 7, 1920, we published Mr. Gillette's deduction of a formula for determining wholesale commodity price levels. It was

$$W = \frac{M \times V}{2 \times P \times E}$$

W = Wholesale price index

V = velocity of money circulation

P = population

E = Efficiency of production per capita.

In a forthcoming issue Mr. Gillette will deduce a formula for determining wage levels.

The wage formula is—

$$w = \frac{0.8 \times M \times V}{P}$$

in which W is the average or index wage (or relative wage), the average daily wage for the year 1860 being taken at 100 per cent. This wage is measured in currency and not in commodities. For a wage (w^1) measured in wholesale commodities, we have

$$w^1 = w \div W$$

Hence

$$w^1 = 1.6\ E$$

This means that the average wage measured in commodities is proportional to the per capita efficiency of production.

The formula for the index agrees very closely with the actual index wage throughout the last 60-year period. Hence it may be inferred that the average wage will drop to a level as much above the prewar level as the per capita currency is above its prewar level. Commodity price level will also settle to the same level, as indicated by the formula for commodity prices.

Per capita currency is now about 70 per cent above the prewar level. There is apt to be some further shrinkage in the currency, probably not below 60 per cent above the prewar level. If the new per capita currency level settles at 65 per cent above the prewar level, then both wages and commodity prices will settle to that level also.

It will be noted that average wages measured in money are not affected by efficiency of production (E), whereas average commodity prices vary inversely as the efficiency of production. Average wages measured in commodities are directly proportional to efficiency of production. The truth of this last statement had long been recognized by economists, but the first verification of it by statistical analysis was given in our issue of April 7, 1920.

Bricklayers and Plasterers Cut Wages.—Organized bricklayers and plasterers of Mobile, Ala., have voluntarily reduced their wages from $10 to $8 a day, giving as the reason the reduction in cost of living.

Book Review

Masonry Structures.—By Frederick P. Spalding, Professor of [illegible] Engineering, University of Missouri. 404 pages [illegible] John Wiley & Sons, New York. 1921. $3.50 net.

A book covering as wide a field as "Masonry Structures" must necessarily be bulky, if it is to treat its subject with any completeness. Even the branches of this field have grown to such dimensions as to require large volumes for their own treatment.

Yet the author tries to encompass this field in a volume of 404 pages. The subject matter is, as a result, treated in a short, concise and almost encylopdaeic manner. Discussions, examples and details so necessary in the treatment of various types of retaining walls, dams and arches, where the design has not completely outgrown the empirical stage, are altogether absent. No amount of formula and numerical examples will make up for the absence of details of actual engineering practice in these structures.

The arrangement of the chapters is systematic. The chapter headings are: I. Development of Masonry Construction. II. Cementing Materials. III. Stone Masonry. IV. Brick and Block Masonry. V. Plain Concrete. VI. Reinforced Concrete. VII. Retaining Walls. VIII. Masonry Dams. IX. Slab and Girder Bridges. X. Masonry Arches. XI. Culverts and Conduits. XII. Foundations.

The presentation is clear and distinct. Advantage is taken of new developments to make the book up-to-date; such, for instance, is the inclusion of terra-cotta construction (in Chapter IV) and the discussion of the contributions of Messrs. Abrams, Edwards and Young to the science of proportioning concrete (in Chap. V).

Three Great Monopolies

There are three great monopolies in the United States, the United Mine Workers, supported by the check-off, the railroad unions, supported by conditions created by the United States Government, and the various building trades unions, supported by the fact that the building owner is a different man each time and does not care to make a contest for the benefit of the next man.

The worst of the three is the last named because it presents a condition that will not work out its own remedy but causes continued hardship to the entire population. The cost of coal being too high, the users of coal, constituting in essence practically the whole population, can inquire into the cause and eventually work out a remedy. The facts in the railroad situation are so big that they will attract attention, particularly when the chief business of railroad officials today is to bring the situation into the limelight. As pointed out in The Iron Age, the railroad payroll, which is altogether too high, is 38 times the special one-half per cent in expected revenue against railroad valuation, the percentage the Interstate Commerce Commission accorded the railroads with a view to encouraging the making of betterments.

In the case of the monopoly of the unions in the building trades, there is no general corrective force. It is really everybody's business and perhaps it is on that account that it develops into nobody's business. For years apprenticing has been restricted and the amount of work done per man has been reduced. High initiation fees are charged for admission into the unions. If everything is not absolutely "right" on a building job, and sometimes when it is, a general strike is called. The owner does not want to contest for the good of humanity, his interest being to get the job done. He hopes he will have no occasion to put up another building.

The propaganda about there being "a shortage of houses" makes the matter worse, as equine sense, not to call it practical psychology, would indicate. Does the propaganda influence the carpenters to work harder or the plumbers to avoid "jurisdictional disputes"? Sometimes a civic body takes up "the housing situation," and invariably in the case of there being a deadlock between seller and buyer because the seller's price is too high, it tries to induce the buyer to come to terms. In Pennsylvania they have a law holding down the interest rate to 6 per cent, and they are trying to get the law changed so as to permit the buyer to pay a higher toll for money to be distributed to bricklayers for laying 700 common brick or 300 face brick a day at $1.50 an hour.

In various communities tens of thousands of men will be idle during the next few months, but beware of employing any of them in building construction! There must be unanimous consent of all the unions in the building trades, or work stops. A few building jobs in each community will give positions to the handfuls of men that have their union cards.

The so-called shortage of dwelling houses represents chiefly a desire on the part of the people to live better. From 1910 to 1920 the population of the United States increased 14.9 per cent. Many houses vacant in 1910 are now occupied. Few houses have been torn down. Many have been built, by the individual and by large employers of labor. The actual accommodations, in proportion to population, cannot have greatly decreased in the 10 years, but men want to live better. They could afford to live better if construction costs were not so inordinately high on account of this peculiar monopoly. If the problem is not solved in the right way, the situation will be met in the wrong way, by people being forced to live in cramped quarters simply because when it comes to building one is not free to employ whom he chooses and work for whom he chooses. If there are not enough artisans, they can quickly be produced in trade schools.—Editorial in The Iron Age.

The Building Guilds as an Architect Sees Them

Mr. Walker, writing in the Architectural Review, dismisses the Building Trades Guilds of England with the somewhat contemptuous remark that they give no "guarantee." This is quite true. On the other hand, for purposes of accuracy, it should be mentioned that their faithful performance is insured, in part, at least to the satisfaction of the Ministry of Health, and it seems undeniable that they are building cheaper and better than in the old way. However, considerations of a financial "guarantee" aside, is not architecture, for example, quite as likely to prosper under the influence of a moral concept, as under the handcuffs of a legalized guarantee? If any industry in the world is today in a more deplorable situation, under the guarantee system, than the building business, it would be hard to find it.

* * *

The English Building Trades Guilds have adventured under a new principle. They will not work for a profit. One may ridicule them and seek to laugh them out of court, if one wills, but the fact remains that they have adopted the one principle which is likely to give any essential promise of good workmanship and an honest result. In spite of all obstacles, natural and contrived, they seem to be building at less cost than under private contract, and so far, none of them have defaulted, nor have there been complaints that their work was not up to the agreed standard. It is even reported by impartial authorities that they are building better, but the test of that statement lies in the future.

Perhaps it is not wise—and certainly it is not fair—to speak contemptuously of a group of men actuated by the very highest motives—the motives of the professional man, who puts service ahead of the reward. The Institute's Canons of Ethics say that "It is unprofessional for an architect to guarantee an estimate or contract by bond or other." If the Guildsmen conceive their work as a professional service to be discharged in the best interest of the common welfare, why should they give a guarantee other than that morally implied in their own canons of ethics? Is it not about time to imagine that perhaps the moral concept is the best one, when all is said and done? Is it not upon the morality of the architect that the client must rely? And who shall say that the morals of Guildsmen are not as trustworthy as those of architects? And last of all, why does the American Institute of Architects tell its members that it is unprofessional to guarantee costs? Because it knows that the professional spirit cannot survive when men become interested in protecting their own guarantee rather than in truly serving those who trust them. For my part, I say God speed to the Guildsmen, whatever may be the end of their adventure, for they carry, to my mind, the one banner which points the way to anything worth while in this sorry world of ceaseless combat over prices and profits, with its endless and fruitless efforts to legalize and guarantee that which can never come to rest except upon the plain and simple base of individual morality—or, in the building industry, the honor of the craft.—From Editorials in the March number of The Journal of the American Institute of Architects.

Einstein's Theory of Relativity

By HALBERT P. GILLETTE, Editor.

Discussions of Prof. Albert Einstein's theory of relativity may be classified as physical and metaphysical. To the latter belong the pseudo-philosophical attempts to show that space is "warped," that time is a fourth dimension of space, and the like. Puzzled by the mathematical expression "four-dimensional continuum," many non-mathematical writers have confused themselves and their readers by vainly attempting to portray four-dimensional space. Equally confusing and equally futile have been their attmepts to depict a "warped space."

I shall confine my discussion, first, to the mathematical results of the theory of relativity, and then to an explanation of the physical significance thereof.

When Prof. A. A. Michelson (an American) showed (1887) that light from an earthly source travels as rapidly in one direction as another, physicists were puzzled. The earth is moving about the sun at 18.6 miles a second, and it was expected that an ethereal "wind" would retard the light waves in one direction and accelerate them in the opposite direction, but the ethereal "wind" apparently had no effect.

G. F. Fitzgerald (an Englishman) suggested (1892) that the null effect of Michelson's experiment might be attributed to a shortening of the earth's dimensions and those of all bodies upon the earth in the direction of the earth's orbital motion, as a result of that motion. Fantastic though this suggestion seemed, Prof. H. A. Lorentz (a Hollander) was able to prove that it accorded perfectly with the principles of electromagnetism. He deduced the following formula:

$$L' = L\sqrt{1 - v^2/c^2}$$

L' is the length of a body in the direction of its motion, measured in terms of its length (L) when at rest;
v is its velocity,
c is the velocity of light (186,300 miles a second).

This formula shows that as a body's velocity increases, its length decreases. If the velocity (v) were ever to equal that of light (c), its length would become zero, or the body would shrink to nothing, in the direction of its motion. In short, the dimensions of bodies in the direction of motion depend upon their velocities. If bodies are moving together in a group at the same velocity, they are all correspondingly shortened, so that there is no means of detecting the shrinkage of any one of them by laying any other of the group alongside. But to an observer not moving with the group the shrinkage of the bodies would be evident if he possessed suitable measuring devices.

The formula shows that if the velocity were to exceed that of light, the length (L) would have an imaginary value (since it is impossible to extract the square root of a minus quantity), from which it is evident that the velocity of light is a limiting velocity which can not be exceeded by any body.

Lorentz also deduced the following formula:

$$t = T : \sqrt{1 - v^2/c^2}$$

t is the time between two ticks of a clock moving with velocity v, measured in terms of the corresponding time (T) of the same clock at rest. This formula shows that as the velocity (v) of the clock increases, the time (t) between ticks increases; that is, the clock runs slower; and were its velocity to become equal to that of light, the clock would cease running. Time, as measured by clocks, therefore, is dependent upon the velocity of the clocks.

If an observer on the earth could see the precise position of the hands of giant clocks on Mars, and if two clocks on Mars were set to run together at one of the poles of that planet, and then one of the clocks were moved to the equator of Mars, the earthly observer would see that the clocks at the equator were running slower than at the pole. Time is therefore not independent of matter, and varies with the velocity of the time-piece.

Pondering the deductions of Lorentz, Einstein conceived his basic principle of relativity, which may be stated thus: Natural phenomena run their course with respect to one observer precisely as with respect to any other observer, regardless of relative velocities, so that natural laws are universally transformable.

Having reached this important generalization, Einstein proceeded to apply the relativity formulas of Lorentz with remarkable results. He deduced the following formula for the kinetic energy (K) of a mass (m):

$$K = mc^2 : \sqrt{1 - v^2/c^2}$$

This formula shows that kinetic energy increases more rapidly than as the square of the velocity (which is at variance with older ideas), and that as the velocity approaches that of light the kinetic energy approches infinity. In other words, it would take infinitely great force to impart to the smallest atom the velocity of light, which is the greatest velocity attainable.

The old formula for kinetic energy is:

$$K = \tfrac{1}{2} m v^2$$

Einstein's formula reduces exactly to this old formula when v is infinitesimal compared with c.

Einstein has shown that gravitation is not an "isolated force"; i. e., unrelated to light, magnetism, etc. He says: "The gravitational mass of a body is the same as its inertial mass. The same quality of a body manifests itself, according to circumstances, as 'inertia,' or as 'weight.'" Light waves are known to exert pressure (have inertia); hence, reasoned Einstein, light waves must be affected by gravitation. Accordingly he calculated the amount that a ray of light from a star to the earth would be deflected by the gravitational pull of the sun; and his estimate was almost exactly confirmed (1919) by English astronomers. Moreover, his energy formula gives twice as great a deflection of a light ray as is given by using the old energy formula. This confirmation of Einstein's prediction is striking proof of the substantial truth of his relativity theory.

Another proof was had when he accounted precisely for the fact that the major axis of the ellipse that Mercury decribes about the sun turns 42 seconds of arc more in a century than could be accounted for by Newton's law.

Newton conceived the existence of a universal ether to explain the action of gravitation across space. Einstein states that since the theory of relativity does not involve the assumption of ether, the etherial hypothesis is unnecessary. However, he curiously admits that "we have come to regard action as a distance as a process impossible without the intervention of some intermediary medium." In the case of magnetic attraction, the "intermediary" is the "magnetic field." In the case of gravitation the "intermediary" is the "gravitational field." But what, may we ask, is ether but an "intermediary medium?" And what is gained by substituting the word "field" for the word "ether"?

Einstein reasons that any accelerating force produces the same effect as gravitation, and this leads him to treat gravitation as if it were purely an acceleration phenomenon. He illustrates his idea by assuming an observer standing inside a closed box in space so far removed from all other bodies that gravitation would be negligible. Then if the box were pulled rapidly "upward" the observer would feel a pressure upon his feet analogous to the pull of gravitation. If he were to let go an object in his hand it would "fall" to the floor of the box, exactly as if earthly gravitation were pulling it. Hence a gravitational "field" is purely an acceleratational field, or inertial mass and gravitational mass are identical. Einstein has accomplished much by thus regarding gravitation. May it not be possible that still more may be discovered if, assuming the underlying identity of inertia and gravitation, we seek the reason for it? Einstein rests with the fact of identity of effect, but other physicists will seek to explain the fact; and the moment of explanations begin, that moment the ether that Einstein has banished will return for reconsideration. Indeed, as above indicated, Einstein has banished "ether" only to substitute "field," and all fields (gravitational or magnetic) may be merely names for etherial motions.

An Explanation of Relativity.—Having briefly outlined the leading principles of relativity, let us attempt to explain why there is relativity. To do so let us assume the existence of an ether consisting of particles moving heterogenously with a mean velocity equal to that of light. Let us admit that our ignorance about ultimate mechanism of phenomena does not warrant the rejection of such an etherial hypothesis, because it seems to conflict with known laws relative to some phenomena, such as the aberration of light.

It was such an ether as this that La Sage conceived, a century ago, in his attempt to explain gravitation. He conceived that it is the impact of ethereal particles on bodies that drive them toward each other; there being fewer ethereal impacts on the faces between two bodies than on their "outside" faces, due to the fact that each body "shades" the other from such impacts. This hypothesis was rejected because it was assumed that such ethereal impacts would heat the bodies, but in the absence of knowledge as to just how the ultimate particles of bodies move when heated, the rejection of La Sage's hypothesis on that score was not philosophic. If heat is a rythmic vibration of ultimate particles, it is conceivable that a bombardment of ethereal particles would fail to produce such rythmic vibration, even as intermittent, opposing pushes fail to swing a pendulum.

We can conceive that during the acceleration of a body the ether in front of it is compressed, but when acceleration ceases the compression speedily ceases. The ethereal pressure thus produced during acceleration is, I conceive, the inertial resistance commonly regarded as being inherent in the body itself. Although the ethereal particles in the compressed "zone" flow away with a velocity equal to that of light, appreciable time is required for this flow to result in normal ethereal pressure in front of the moving body. As the velocity of an accelerating body approaches that of the ethereal particles themselves, the ethereal pressure that causes inertia increases faster than the square of the velocity of the body, and the "zone" of ethereal pressure extends to a correspondingly greater distance. Were a body accelerated to a velocity equal to that of the ethereal particles, the zone of ethereal pressure would extend to the limits of the ethereal universe. This is my explantion of Einstein's formula for energy, and indicates why the limiting velocity is that of light.

When a body is retarded, the converse phenomenon occurs. The ether becomes compressed behind the body during the period of its decreasing velocity, and it is this ethereal compression at the rear that produces the inertial push of a moving body when it strikes another. Both acceleration and retardation are therefore the consequences of ethereal pressure, that is, impact of ethereal particles.

During the period of acceleration when the ethereal pressure in front of a body is increasing, the particles of the body are forced closer together in the direction of bodily motion, much as a flexible balloon is compressed when propelled against the air. This is my explanation of the shortening of bodies as their velocity increases, and makes clear the reason for the Lorentz and Einstein formula for decreased length in the direction of motion.

The ultimate particles of a body either move in orbits or vibrate, or both. In any case, the ethereal pressure in front of an accelerating body retards the velocity of motion of the ultimate particles in the direction of bodily motion, and increases their velocity in the opposite direction. The effect of this is to make the velocity (V) of a bodily particle plus the velocity (v) of the body always a constant and equal to the velocity (c) of the ethereal particles. This means that the velocity of an ultimate particle of a body is always equal to that of a particle of ether. Hence it follows that light waves in the ether originate with a velocity that is constant. The same reasoning holds true for reflected light.

I have deduced from a well known formula for sound and another for velocity of gas molecules, that the velocity of sound in a gas is 0.7 of the velocity of the molecules of the gas. Experiments confirm this deduction. Similarly I have deduced by analogy that the velocity of light is 0.58 times the velocity of the ethereal particles, thus leading to the conclusion that the latter have a velocity of 320,000 miles a second. This is mentioned in passing, because it should not be inferred that the velocity of light is the same as that of ethereal particles, but only that it bears a constant ratio thereto.

Einstein's Formula for Energy.—In seeking the greatest possible generality for his formula for energy, Einstein has deduced the following:

$$K = (m c^2 + E) \div \sqrt{1 - v^2/c^2}$$

The factor E is the radiant energy absorbed by a body without altering its velocity. He concludes that the mass of a body is thus increased by E/c^2, and that a body's mass, therefore, is not a constant as hitherto supposed. This also can be explained by the ethereal hypothesis above outlined, for if the absorption of radiant energy involved the absorption of ethereal particles by the body, and if the ultimate particles of a body are also "bound" ethereal particles, all moving with a mean velocity equal to that of light (or a constant multiple thereof), then it follows that the internal energy of a body and its mass are interchangeable terms. Thus, reasoning deductively from our ethereal hypothesis, we come to the same conclusion that Einstein reaches.

Einstein says: "The general theory of relativity renders it likely that the electrical masses of an electron are held together by gravitational forces." But if our ethereal hypothesis is sound, we may carry this generalization even farther, by stating that every condition of equilibrium is one of balancing ethereal impacts, gravitation being merely one species of ethereal impact phenomena.

If all transfers of energy are merely transfers of ethereal impacts from one "system" (body or ethereal wave) to another, not only are the principles of Einstein's relativity explained, but many of the elementary principles of mechanics cease to be mere statements of fact, and become picturable. Thus "action and reaction are equal and opposite" because bodies act upon one another through the medium of an ether in which they are immersed, and of which, indeed, they are a part.

Time as a Fourth Dimension of Space.—Probably no part of Einstein's theory has aroused more discussion among laymen than the relationship between space (distance or dimension) and time. Among most physicists, however, this relationship is accepted as a matter of course. Time is measurable only by counting the number of recurrences of some rhythmic motion. Time can be roughly measured by counting pulse beats, and accurately measured by counting the swings of a pendulum. Although it is possible to ignore the time factor when it is a constant, time is never a thing apart from matter. Matter is always in motion of some sort, and motion involves both time and distance. Hence time and distance are really inseparable factors. Where the time element of two "events" is equal, the reasoning about them may be confined to their spatial characteristics. We do this in geometry. Where the dimensional factors of two "events" are equal, we may confine our observation and reasoning to the relation of time factors only. We do this when we compare times. But ignoring a constant element in making comparisons is not equivalent to eliminating it from existence, nor is it equivalent to tacitly affirming that the given element can exist apart from all other things. This distinction is important in philosophising about any abstract idea, and particularly so where space and time are being considered. There are no such things as absolute ("pure") space or absolute time. This was clear to many reasoners long before Einstein's theory of relativity was announced. Although this theory gives mathematical relationships between time and spatial factors that appear to be quite novel, yet careful consideration will disclose that the time and distance factors in his time transformation formula

$$t = (T - v\,d/c^2) \div \sqrt{1 - v^2/c^2}$$

are necessarily there because it requires time for light to travel the distance (d) between two clocks that are moving relatively with the velocity (v), a light signal being the means adapted to synchronize the clocks. There is nothing mystic in such a formula, except to men who are not accustomed to applying mathematics to physical problems.

Similarly, the use by Einstein of a geometrical device called Gaussian co-ordinates, and of Minkowski's application of the Gaussian system, have served still more to confuse non-mathematicians. Examples of this confusion abound in most of the books and articles written to "explain" Einstein's theory in a popular manner.

The expounding of a profoundly mathematical theory can not be satisfactorily accomplished in non-mathematical terms. The best that can be done is to outline the premises and the conclusions, giving in addition, if possible, a picturable account of how the co-acting forces operate to produce the results. In a theory so far-reaching as Einstein's, only a selected part could be thus presented in this article. Einstein's book on "Relativity" is now available in English, which, with Eddington's "Space, Time and Gravitation," will serve as an introduction to Einstein's epochal theories.

Endurance Tests of Concrete Floor Treatments.—A mimeographed circular has been issued by the U. S. Bureau of Standards, Washington, D. C., describing endurance tests of various treatments for concrete floors. In addition to this work, experiments have been started to determine the effect of various methods of applying a few of the common treatments used for preventing dust and excess wear on floors of this type. The object of the work is to determine if simpler or more effective methods can be discovered for applying these treatments.

Types of Foundations

By CHARLES EVAN FOWLER.
Consulting Engineer, New York City.

The discussion in the preceding article in the March 16 issue of Engineering and Contracting of the various elements that influence the selection of the type of foundations, has especial reference to the methods to be used in constructing bridge foundations, but the same general features are common to this portion of all structures to be designed by either the engineer or the architect. Therefore the following detailed discussion of the types of foundations will be found to comprise the fundamental principles that must be considered in deciding upon the type of foundations not only for bridges but for the great variety of other engineering structures, and also for buildings and structures of any class, where water must be the principal thing to be contended with and the consequent troubles surmounted. When the proper solution has been found, the possibility of ensuing troubles will, within reasonable limits, have been fully discounted. The principal types for obtaining a foundation are: (1) the earth bank cofferdam; (2) the log crib cofferdam; (3) the sheet pile cofferdam; (4) the removable box cofferdam; (5) the crib cofferdam or tubular pier; (6) the open dredged caisson; (7) the diving bell caisson; (8) the pneumatic caisson; (9) the combined open dredged and pneumatic caisson; (10) the ballmatic caisson; (11) the freezing process; and (12) the grouting process.

Class of Construction.—The class of construction to be employed is not necessarily the first feature to be decided, nor is it often possible to decide it first hand, as it may prove necessary to make several designs and comparative cost estimates before a decision can be made as to whether to use timber, metal, or concrete in constructing the cofferdams, cribs, or caissons. However, it may be possible at this point to indicate the basis for determining what investigations in this respect are advisable.

The use of timber sheet piles in a timber country is usually the cheapest, unless the steel sheet piles are already at hand, in which case they would probably be cheaper, as they can usually be salvaged and used again or sold, whereas if timber is used it is usually of little value after removal, although in the case of heavy 10 or 12-in. sheet piles with dove-tailed tongue and groove spiked on, the writer has used them a second time with good results. However, there are frequently cases of hard driving or where absolute strength and water-tightness are necessary, in which it is advisable to use steel sheet piles, even if the net cost will be greater.

The case is quite different in other than a timber country or where steel is cheap; and usually in such a location the steel piles are cheaper and also much better than the second grade timber that must often be accepted. Many contractors now carry steel sheet piling as part of their plant, or else it can be bought second hand and sold again at little net cost or at times with a profit. The engineer should, however, never allow the use of old steel sheet piling of doubtful quality or of too short length, as the owner in such cases will surely be the one to suffer loss, either directly or by reason of having to accept inferior work that may result.

The use of reinforced concrete sheet piles will seldom if ever be found cheaper or desirable in any class of cofferdams unless they can economically or must necessarily be made a part of the permanent construction. They might prove economical, for example, in sea wall construction where they would form the face of the wall, or they might prove necessary in cases where the pulling of the sheet piles would damage the permanent construction.

LIMITS FOR FOUNDATION METHODS.

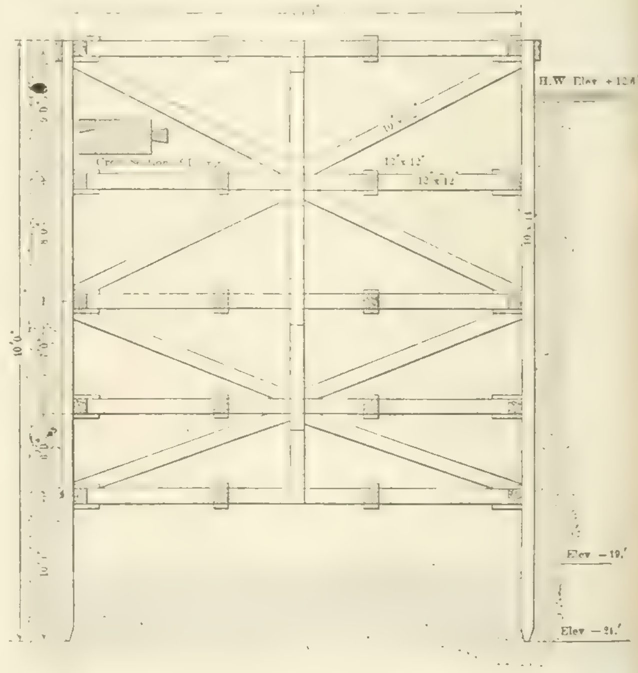
	Min. depth. Ft.	Economic max. depth. Ft.	Max. possible depth. Ft.
1—Earth bank cofferdam...	1	[illegible]	8 to 10
2—Log crib cofferdam	4	14 to 16	20 to 25
3—Sheet pile cofferdam ..	5	[illegible]	25 to [illegible]
4—Removable box cofferdam	5	10 to 12	15 to 20
5—Crib and tubes..........	5	[illegible]	30 to [illegible]
6—Open dredged caisson	20	80 to 90	250
7—Diving bell caisson..... ..	10	[illegible]	80
8—Pneumatic caisson... ...	20	[illegible]	110
9—Comb. op. and pn. caisson	20	[illegible]	110
10—Ballmatic caisson. ..	60	[illegible]	250
11—Freezing process.........	[illegible]	[illegible]	125
12—Grouting process . .	1	[illegible]	125

The decision as to the kind of material to use in constructing caissons can not usually be arrived at without some preliminary designs and estimates having been made, and this is particularly true for large caissons, or for those that must be sunk to great depths and that must withstand great pressures. However, the designer need have no fears, nor feel that he is out of date, in using timber when it is the cheapest as well as the quickest obtainable material, and if it will give the proper strength.

Single walled cribs or open caissons must usually be made of timber; and for small caissons its use will prove perfectly satisfactory, or even for medium sized ones up to about 20 ft. by 80 ft. Yet the fact must not be lost sight of that such construction must be even more carefully designed than when using concrete or steel. The use of reinforced concrete for caissons is steadily increasing, because the materials are usually easily and cheaply obtainable in almost any locality. Therefore the question of using it depends very largely upon its comparative cost, and its adaptability to the type of caisson. Greater economy may often be obtained by using it for circular, oval, or elliptical caissons, the ease of sinking them being thus greatly increased, and the maximum allowable pier weight not exceeded.

There will still be found cases where steel may prove desirable for small cylindrical piers, although reinforced concrete is well suited to such use if it proves to be no more expensive.

The use of steel at ordinary prices will often be found desirable when timber is not very cheap or close at hand for ordinary rectanguar caissons; and particularly so for large rectangular ones when the strength must be surely known. This is shown in the Antwerp quay wall caissons, which were undoubtedly the cheapest type for that work and which enabled the construction work to proceed without any particular troubles or delays. Where very large caissons are to be employed, similar to those of the Forth Bridge piers, which were cylindrical of 70 ft. in diameter, from 50 ft. to 60 ft. in height, and were sunk by the pneumatic process to depths as great as 89 ft. below water, then steel is the only material that should likely be used, as it can be used in forms and details of construction that will safely stand great pressures, and large stresses of distortion; as was proven by one caisson of the Forth Bridge tipping partly over without eventual damage. The use of steel is also desirable for constructing caissons which are to be sunk to great depths; such as the Hawkesbury, Australia piers, which were of oval section 20 ft. wide by 48 ft. long, and were sunk to a depth of 155 ft. below water by open dredging.



Single Wall Cofferdam.

Earth Bank Cofferdams.—The earth bank cofferdam, as

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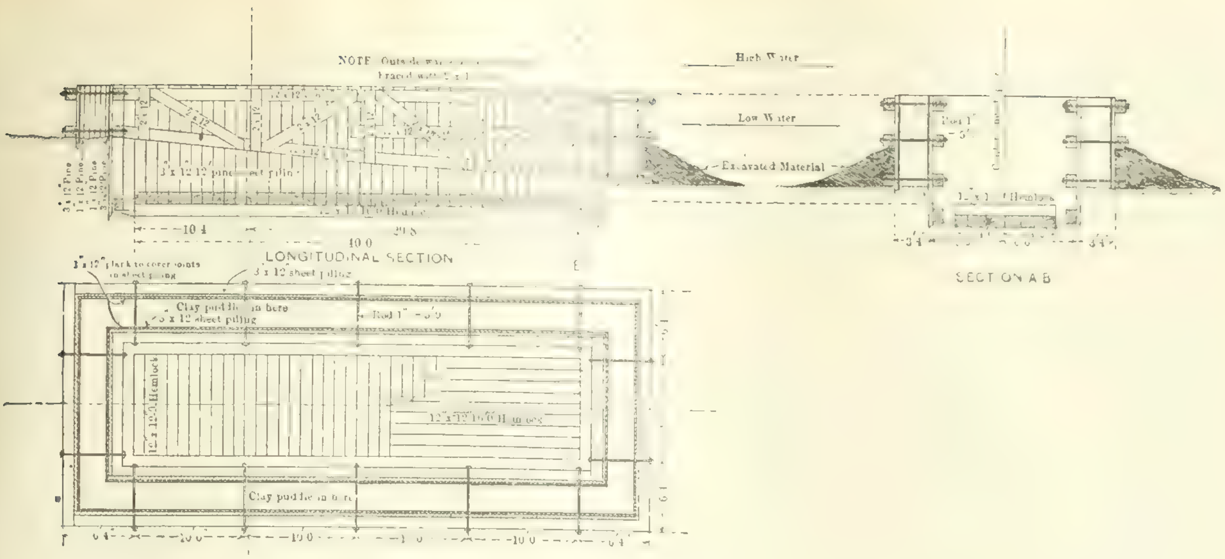


Cofferdam With Puddle.

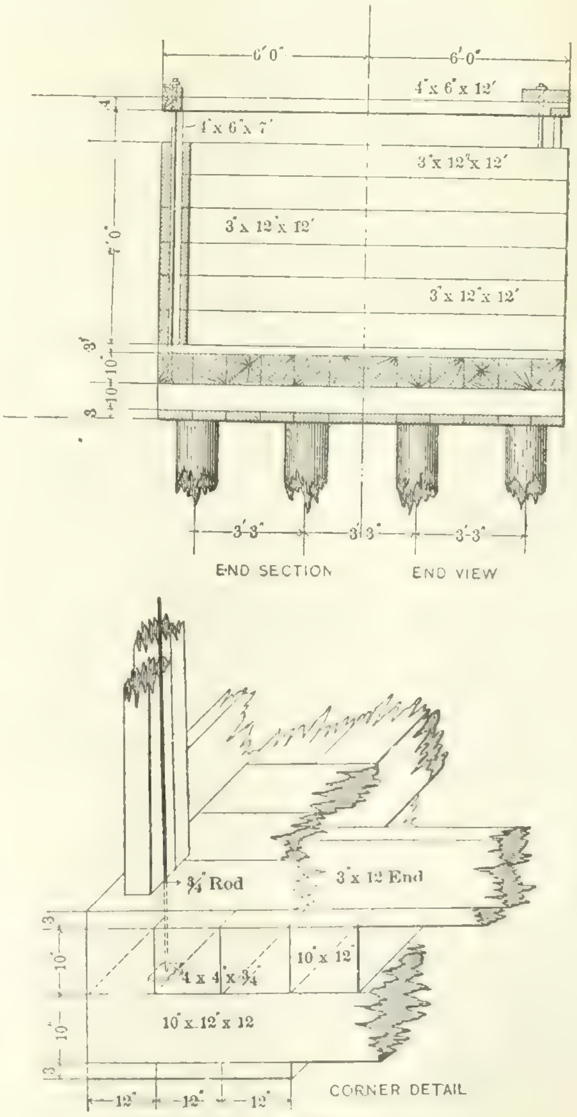
shown in Fig. 4 of Vol. I of Engineering and Building Foundations, is the simplest method of excluding water from a foundation or by which the water to be pumped may be reduced to a very small quantity. The earth bank should consist of clay, sand, and gravel, with enough clay to make the bank water tight, and enough gravel to give the weight necessary to assist in closing leaks. This method can be successfully used for heads of a few feet, up to a maximum of 8 or 10 ft., when the material for banking up is very good, when the water outside has little current and is still, and when the seepage is not great. After the bottom has been bared of water, and the excavation carried to the proper depth, which should be below any possible scour, then the foundation courses can be placed, if the bottom will carry the required load per square foot. Should the bottom be too soft for carrying the load directly, a grillage of timber is often placed below low water mark to spread the load; a reinforced concrete spread base may be placed; or else enough piles must be driven to carry the load, without considering usually the bearing capacity of the intervening material or bottom soil. Should it be considered possible for scour to ever reach down to the piles, then rip-rap protection must be placed.

The writer has used a modification of the earth bank cofferdam in a stream where there was considerable fall or a small rapids, by forming a semi-circular bank or dam out in the stream with sand bags, leaving the down-stream side open. Due to the slope of the bottom, the area inside was naturally freed from water so that work could readily proceed.

Log Crib Cofferdam.—The log crib cofferdam is next to the simplest type, and should be used when there is a greater depth of water than 8 or 10 ft., or where there is considerable current or rough water; but for a depth usually of not more than 16 ft., or possibly some greater when all the conditions are of the best. The log crib may be built up of rough logs or old bridge timbers, and drift bolted together so as to resist the current and static pressures, and to bind the earth filling together, as well as to prevent its being washed out by the current. The filling should be of clay and gravel mixed, as described for the simpler earth bank cofferdam.

The cofferdam of this type used for the Kanawha River dams, and that used by the writer in the Green River work are described in Chapter II of Vol. I of Engineering and Building Foundations. The ones on the Kanawha were of very strong construction and the excavation was carried down to a depth of from 20 ft. to 24 ft. below low water; but this must be considered as an exceptional case, and not economical except in a case where the logs could be readily obtained and for a very low cost. The one at Green River was built of small logs which were cut at the site, and most of the filling was clay and shale from the mucking of a tunnel adjoining. The excavation was carried to a depth of about 15 ft., and considerable leakage resulted. Some short sheet piles were driven inside to retain the fill, and the leakage near the top was carried away by a ditch on the inside slope, which discharged the water at the down-stream side; as the large fall in the river for the length of the cofferdam allowed sufficient grade in the ditch.

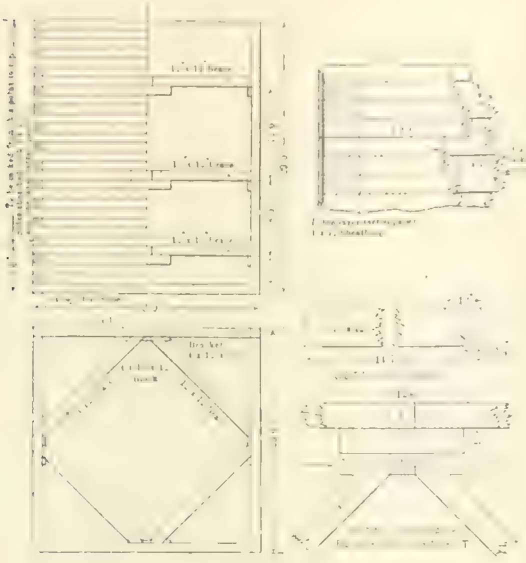
The method is more or less a rough and ready one, that can be employed in new country or as an emergency method where timber can be cheaply obtained, but it is not advisable to consider it in ordinary cases for depths greater than 16 ft., unless, as has been stated, the conditions are all favorable and great care is used in the construction. When



Box Cofferdams.

the excavation is to be carried a considerable depth below the bed of the stream a wide enough bench or berm on the inside must be allowed for stability.

Sheet Pile Cofferdam.—The use of sheet piles of wood and steel for constructing cofferdams has been covered comprehensively in several of the writer's books on foundations. Sheet pile cofferdams without puddle, formed of a single wall of some approved form of sheet piles, of proper thickness or strength and properly braced, should not generally be used for a depth below water greater than 15 ft. Where they can be driven some distance into reasonably impervious material, or good material can be banked up around the outside, they can be used for depths up to about 30 ft., but unless the material at the bottom is reasonably watertight and non-water bearing, or unless a seal of concrete can be used, it will usually be found very difficult to pump out such a cofferdam; and if it can be done the cost may prove to be very great, thus indicating that an open dredged or pneumatic caisson should have been used. The use of double or triple walled sheet pile cofferdams, with a puddle of clay and gravel between, has in years gone by been extended to 40 ft. depth below water, but with the modern caisson methods now available, they would prove uneconomical and unsatisfactory; so that the maximum limit should usually be placed at 20 ft., and in particular instances at 24 ft. depth. The decision to use one being arrived at only after careful estimates covering all probable difficulties. Should it ever be found desirable to use a puddled cofferdam for a depth greater than 20 ft. and where three rows of sheet piles would seem desirable, the outside row need not be extended to the full height. The final caution would be that sheet pile cofferdams are never as simple a method of obtaining foundations as they seem.



Single Wall Dredged Crib.

Removable Box Cofferdam.—The use of removable box cofferdams is not very general, but frequently they can be employed to advantage, as described in Chapter II of Vol. I of Engineering and Building Foundations, and which is particularly applicable where foundation piles have been driven and cut off to a level for receiving a grillage. The grillage can be made as the bottom of the box, which is sunk onto the piles, and after pumping out, the grillage can be drift bolted to the piles and the masonry laid. Then the bolts are loosened, the sides floated loose and can be used again. Similar construction can be carried out with steel cylinders having the grillage as a bottom; which when sunk onto level piling can be pumped out and filled with concrete.

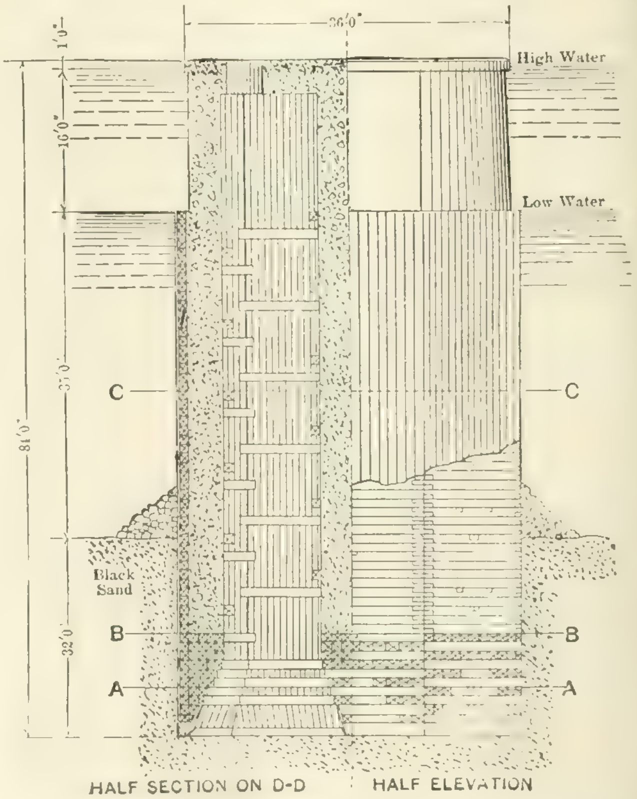
Crib Cofferdams.—The use of crib cofferdams is seldom advisable for depths greater than 20 ft., and in any case they frequently should be replaced by open dredged cribs. The construction of a crib cofferdam is usually similar to a log crib except that it is made of sawed timber laid close, and sheeted or calked so as to be water tight. They are frequently made double walled and not calked, but made water tight by the use of a puddle of clay and gravel between the walls. The use of them may be extended to depths of 25 to 30 ft. below water, but seldom with economy.

The use of steel tubular or cylinder piers is a method analogous to using crib cofferdams, and they were very much in vogue some years ago, but now it is only in exceptional cases where some modern type of reinforced concrete construction will not be found better and more economical.

Cylinder piers are usually very cheap to construct, very easily placed, and with piles driven inside they have been known to stand after the material has scoured out below the bottoms of the tubes. The piles may first be driven and the cylinders set over them, but if a really good foundation is desired, the tubes should first be sunk by dredging out the material from inside to below scour, with an orange peel bucket or hydraulic elevator as the sinking proceeds and the piles then driven and cut off; or else driven with a follower to the allowable elevation within the pier. The writer considers the patent reinforced concrete cylinder pier vastly superior, and it can now be constructed free of any royalty payment.

Open Dredged Caissons.—The use of open dredged caissons has developed rapidly with the increase in cost of pneumatic caissons, due largely to the increase in wages. Where the material through which a caisson is to be sunk is not too hard to be dug economically by means of modern self closing clam shell buckets, the sinking can be done rapidly and economically. When it is comparatively soft, much of the excavation can be done economically with hydraulic elevators, which are particularly valuable in cleaning up or reaching loose material that does not readily flow to a dredging bucket. The type of bucket referred to will dig through sunken logs if they are not too firm, and only occasionally is it necessary to apply air to an open dredged caisson.

The single walled type such as were sunk by the writer at Tacoma, are in reality dredged cribs and they must be built strong enough to withstand the pressures and racking stresses, as well as the loading on top to overcome skin friction. This type is applicable to depths of from 50 to 60 ft. below water level, but beyond this depth they should be of the double walled type, and filled between the walls with concrete to give them weight for sinking, or else be built of reinforced concrete with enough wall thickness to give the necessary weight.



Open Dredged Caisson.

The pivot pier of the Frazer River bridge at New Westminster, B. C., was landed in 70 ft. of water and sunk to a total depth of 125 ft. below water. The piers of the Hawkesbury, Australia, bridge were built with metal caissons and sunk to depths up to 185 ft. below high water. Thus the method of open dredging is found to be suitable for any depth from 20 ft. up to such a maximum depth as is necessary to reach below scour, and to reach to a depth where the confined bearing capacity of the soil, assisted by a conservative allowance for skin friction, will support the load and resist the eccentric pressures with a proper factor of safety. The real maximum limit for depth of sinking by the use of the open dredging process would be that depth at which the weight of the pier and possibly loading would no longer overcome the skin friction, and the pier refuse to sink further. The greatest depth recorded is 256 ft. for a coal shaft sunk in Germany. The reasons for substituting the pneumatic process for that of open dredging will be given in the section on pneumatic caissons.

Diving Bell Caissons.—The use of diving bell caissons is usually restricted to special cases where a submerged foundation must be built without regard to incorporating in the method the construction of the pier shaft or other masonry superstructure. The diving bell was one of the earliest means employed by engineers for foundations under water, as described by the writer in several publications, where they were found to have been used by Smeaton nearly 150 years ago, and by Rennie over 110 years ago. The most recent use of this method was in the reconstruction of the B. & O. R. R. bridge over the Allegheny River, where the design was a composite of a diving bell and a pneumatic caisson. The greatest difficulty in its use will usually be found in sinking it evenly, or in other words keeping it plumb.

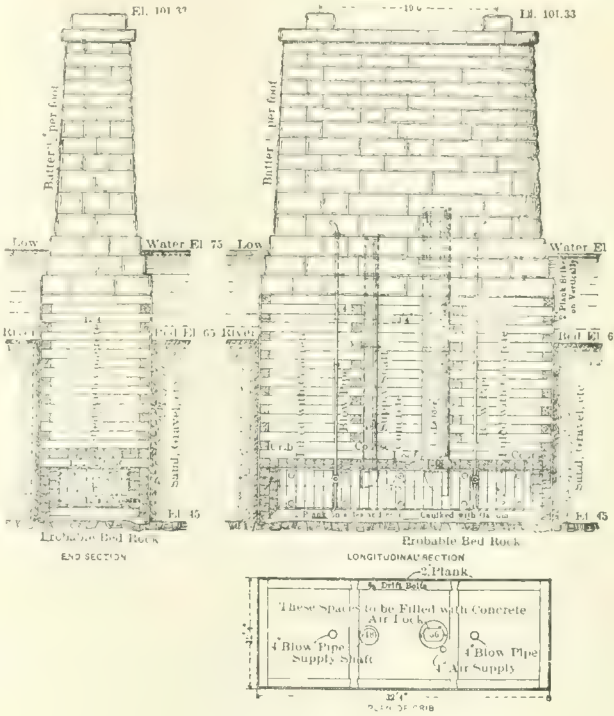
Pneumatic Caissons.—The pneumatic caisson may be considered as covering the same range of depths as the open dredged caisson, up to its maximum practicable limit of 110 ft. This maximum depth being fixed by reason of the large consequent air pressure at this depth of about 50 lb. per square inch, being the greatest under which men can do effective work; and then the working periods must be reduced to less than two hours for each shift. The reasons for the adoption of the pneumatic process as against other methods, are first, the more sure and positive character of sinking; second, the possibility of workmen within the caisson cutting through obstructions and hard strata which could not easily be removed by dredging; third, the reduction of the opposing skin friction by reason of the compressed air which escapes under the cutting edge reducing the friction as it comes up around the sides of the caisson; fourth, the possibility of actually seeing, testing, and preparing the bed on which the pier will rest. Although air can be applied to open dredged caissons near the landing depth, so long as this does not exceed 110 feet below water, and this same purpose accomplished. Frequently under normal conditions as to the cost of labor and material, when contractors have all of the plant for pneumatic work, including air locks and shafts, they are able with especially skilled workmen to construct foundations as cheaply by the pneumatic as by the open dredged process, providing of course that the material is such that it can be largely removed by sand pumps.

Combined Pneumatic and Open Dredging.—The designs for the construction of foundations by the open dredging process, should provide for applying compressed air if there is a probability of encountering obstructions or very hard strata, or if the unit loads are so great as to make it desirable to see, to test, and to especially prepare the foundation bed.

The need for overcoming and removing obstructions was the cause for applying air to the cast iron cylinders of the Merrimac River bridge. The four fixed span piers consisted of pairs of cast iron cylinders 8 ft. in diameter by 1½ inches thick. They were sunk through sand and gravel by open dredging with an orange peel for depths up to 45 ft.; but when boulders were encountered, the cylinders were fitted with air locks, loaded down with pig iron, and the sinking completed by the pneumatic process.

The sinking of the piers for the Beaver Cantilever proceeded very slowly with an orange peel bucket, so that stone was piled on to overcome skin friction and jets were used under the cutting edge. When within less than 2 feet of the rock, it was decided to complete the work and prepare the foundation bed by the pneumatic process. The water was pumped down in the dredging wells to within 10 or 12 ft. of the bottom, and timber decks built across the wells. Air shafts carrying locks were fitted to these decks, concreted in, and the work completed under air pressure. The use of similar methods will frequently make it possible to use the open dredging process for the greater part of the work when it will be the cheaper process to employ.

Ballmatic Caissons.—The combination of ballast and air tanks in connection with open dredged caissons, has been termed by the writer ballmatic caissons. These tanks are constructed in the side walls of the caisson proper, spaced equally around the four walls or the circumference; they are connected by air and water pipes with the top, and have outside valves which are also operated from the top. The purpose of the tanks is to aid in keeping the caissons plumb, by either filling the tanks on one side with water; or if all the tanks are filled, by forcing the water out of the tanks on one side by turning in compressed air after the outside valves are opened. The same idea can be used in connection with large pneumatic caissons, but the tanks are particularly applicable to caissons constructed of steel or reinforced concrete. The air and water pipes can also be connected with the side and cutting edges to assist in the sinking, but it is well to observe that many attempts to employ water jets in cutting edges have failed because of lack of enough pressure. The pumps used for this purpose must be of special type, capable of delivering water at a pressure of from 200 to 500 lb., depending upon the firmness of the material through which the caissons are being sunk.



Small Pneumatic Caisson.

Freezing Process.—The freezing process is a method of constructing a foundation, which was invented and patented by Poetch in 1883, and consists in sinking a series of specially arranged refrigerating pipes around the foundation area and freezing a shell of material to the required depth, within which the excavation can be made and the foundation built. The method has been used principally for sinking shafts through quicksand or other water bearing strata. While it has been used in many cases to depths of about 300 feet, and in one case to a depth of 816 feet, it is believed that it could be used practically in particular cases for bridge and building foundations to depths up to 80 feet deep and probably to maximum depths of 125 feet.

Grouting Process.—The grouting process may be considered analagous to the freezing process, and consists in forcing cement grout into loose foundation soil, loose rock, or boulders. The method can be used to enclose an area which is to be excavated, or else the entire foundation area can be grouted to sufficient depth to form the foundation bed proper. The method can be used for depths up to 60 feet without particular trouble or expense, but can be used practically to depths of 125 feet or more. Neither this nor the preceding method should be used instead of the usual methods, without careful study and consideration.

Recommended Practice for Concrete House Construction

At the convention of the American Concrete Institute last month the Committee on Concrete Houses, of which Emile G. Perrot is chairman, submitted as its report a tentative draft of recommended practice for concrete house construction. The report is confined to a consideration of the monolithic, unit constructed and plastered or gunite types. It probably will be revised before its final presentation and adoption by the Institute. The main features of the report follow.

This recommended practice shall apply to the construction of houses not over three stories in height and not exceeding 30 ft. in height between top of first floor and under side of third floor ceiling.

(a) Basement and foundation walls of monolithic concrete shall be not less than 6 in. in thickness and shall be supported on a concrete footing or basement floor sufficient to prevent settlement of the building. The design of these footings shall be based on the ability of the foundation soil to carry loads and the monolithic character of the concrete wall and footing or basement floor shall be considered in determining the required bearing area on the soil. Basement walls shall be designed to resist the horizontal pressure of the earth in contact with the exterior of the wall.

(b) Basement walls of precast units bonded together by registering or interlocking projections or depressions, grouted in place, or by reinforcing bars across joints embedded in cement mortar, shall have a minimum thickness of 7 in., or not less than the minimum thickness of exterior bearing wall of superstructure. The precast units shall conform in strength, quality and absorption to the requirements of Recommended Specifications and Building Regulations presented by the Committee on Concrete Products of the American Concrete Institute.

Note 1.—Allowing a total of 50 lb. per square foot roof load, 75 lb. per square foot for second and third floors, and 100 lb. per square foot for first floor, including weight of walls, the unit compressive stress per square inch on a 6-in. basement wall would be slightly in excess of 100 lb. The unit stress produced by the overturning effect of the wind on the side of the house would not materially increase this. The effect of the pressure on earth filling against the house is in a majority of cases small as compared with the vertical load of the superstructure and cannot materially affect the stability of a monolithic or properly bonded precast unit wall.

Walls.

(a) The thickness of single exterior bearing walls of plain concrete shall be not less than 4 in. thick, but when reinforcing in excess of 2 to 1 per cent is used, the thickness shall be determined by the usual methods of reinforced concrete design for vertical loads and for a uniform wind load of 30 lb. per square foot on exposed surface.

(b) The thickness of the bearing wall, of double or triple concrete walls shall conform to paragraph (a), this section, except that the thickness required to carry the loads may be reduced by the actual working shear value of ties between the walls.

(c) Exterior walls which act merely as curtain walls between reinforced concrete columns or studs shall be designed to withstand a wind pressure of 30 lb. per square foot on the exposed surface. Reinforced concrete curtain walls may be constructed by plastering and back plastering on expanded metal or wire mesh reinforcement, or shot with a cement gun or by other mechanical means of placing concrete or stucco.

(d) Exterior walls of precast units bonded together by registering or interlocking projections and depressions, grouted in place shall conform in thickness to the schedule of wall thicknesses provided for concrete block, brick, tile and architectural trimstone of the Recommended Building Regulations presented by the Committee on Concrete Products of the American Concrete Institute, except that large or small reinforced concrete units connected on two opposite ends to structural members designed to carry all loads to foundations originating from the weight of the building or from wind pressure or which in themselves act as structural members may have a thickness determined by the bending stresses produced by wind pressure of 30 lb. per square foot on the exposed surface.

(e) Solid concrete exterior walls shall be furnished with furring on the inside so as to produce an insulating air space between the interior finish and the concrete wall. Double exterior concrete walls, providing a dead air space between, may be finished without further provision for insulation.

Floors.

Reinforced concrete floors shall be designed to carry a live load of 40 lb. per square foot uniformly distributed. The advantage of continuity in reinforced concrete floors shall not be assumed unless the concrete is placed continuously over intermediate supports for the entire length of the floor, with appropriate reinforcing to take care of negative moments.

Roofs.

(a) Flat concrete roofs shall be designed to carry the dead weight of the roof and 20 lb. per square foot additional for houses constructed in climates subject to heavy snowfall Sloping roofs shall be designed for 30 lb. per square foot on the vertical projections of the roof surface exposed to the wind.

(b) Concrete roofs without other covering shall be constructed of non-porous aggregates so graded as to produce a dense, impervious concrete. For additional assurance of watertight construction, waterproofing compounds may be used. Reinforcement to the amount of .2 of 1 per cent shall be placed in the top portion of the roof slab to resist temperature stresses.

Materials.

(a) Only standard portland cement, which meets the requirements of the Standard Specifications for Cement of the American Society for Testing Materials, in effect as of Jan. 1, 1921, shall be used in the construction of houses.

(b) All aggregates shall be clean material, free from dust, ashes, lumps of coal, vegetable loam and organic matter.

(c) Cinders may be used as coarse aggregate for partitions and for exterior walls, providing tests show the resulting concrete will average a compressive strength of 10 times the loads to which it will be subjected. Cinders shall be composed of hard, clean, vitreous clinker, free from sulphides, unburned coal or ashes.

(d) Slag used for coarse aggregate shall be clean, dense, air-cooled blast furnace slag containing not more than 1.3 per cent of sulphur and shall weigh not less than 70 lb. per cubic foot when loosely packed.

(e) Rods and bars used for reinforcing shall conform to the requirements of the Specifications of the American Society for Testing Materials for Concrete Reinforcing Bars in effect Jan. 1, 1921. Cold drawn steel wire, made from billets, may be used in floor and roof slabs, column hooping and for temperature and shrinkage stresses. Wire mesh or expanded metal may be used for its full cross-sectional value to resist stresses, providing its component parts meet the requirements for tests for concrete enforcement bars of the American Society for Testing Materials.

(f) The water used in mixing concrete shall be free from oil, acid, alkalies or organic matter.

Design.

The design of floors, roofs, beams, girders and columns shall be governed by Section 4, "Design," of the American Concrete Institute Standard Specification No. 23.

Construction.

(a) Reinforcement shall be properly located and secured against displacement during the placing of the concrete.

(b) Machine mixing is to be preferred, but where it is necessary to mix by hand, all ingredients shall be turned together until the mass is homogeneous in appearance and color. Hand-mixing shall be done without losing an appreciable amount of mortar. A small batch mixer is most satisfactory.

(c) Only enough water shall be used to produce a consistency such that the concrete will flow sluggishly into the forms and around the reinforcement without separation of aggregates from mortar. Concrete shall be protected against rapid drying out and shall be protected against freezing until it has hardened for at least 10 days in a temperature not less than 35° F. Concrete shall be deposited in the forms not more than 30 minutes after mixing.

(d) Forms shall be substantial and sufficiently tight to prevent leakage of more than 1 per cent of the mortar. They shall not be removed until the concrete has hardened sufficiently to sustain without injury to the concrete the loads that will come upon it. Window and door frames may be set in the forms and the concrete cast around them. Wooden frames should be well primed and should be anchored to the concrete by means of long spikes or bolts. They should be braced against distortion from the pressure of fresh concrete.

Suggestions on Designing of Forms for Concrete Work

Better designing of forms was the subject of a paper presented February 17 by Mr. T. Trueman Black, Construction Engineer, Toronto, Ont., before the Toronto branch of the Engineering Institute of Canada. An abstract of the paper follows:

Forms are to be designed so as to (1) keep the semifluid concrete in position; (2) give the concrete such surface as is required by the specifications; (3) support the steel reinforcing; (4) be easily removable without destroying or injuring the concrete surfaces; (5) be cheaply built, erected and removed and (6) be in shape for reuse.

There are certain well known theories and principles underlying the design of forms; but there is a number of other factors depending upon local conditions which will determine the success or failure of the work. For instance, concrete will at one time flow easily, filling the forms completely. At another time, however, due to changes in humidity or temperature, or to slight changes in the aggregate, the concrete seems to have developed a large internal friction, flows through the chutes very sluggishly at the same time sets soon after leaving the mixer. In this case the tamping and spading required to fill the forms brings on them stresses which can only be guessed at. The concrete not being spread evenly throughout the forms, brings uneven loading on them.

To meet some of these conditions the engineer has to make a study of:

Type of structure, whether mass work or other walls. In mass work the forms are heavy, coarser aggregate is used requiring fewer cross-ties. In thin walls, beams, etc., cross-ties can be placed frequently, great strength in the forms is not required on account of the small unsupported spans.

Surfaces. Contractors concede that it is cheaper to make smooth exposed surfaces by using forms with finished surfaces, than by smoothing the concrete after the forms are removed.

Advisability of designing forms so as to be able to re-use them.

The action of cement, whether it is slow or quick, whether it throws the surplus water quickly or not, will make a difference in the pressure against the forms. A quick setting cement has a tendency to produce water streaks upon the surface of the concrete. If the form is tight this effect will be more marked. This is especially evident in steel forms. A slight leakage in the form will improve this defect.

In warm weather the tendency for the cement is to set quicker, causing more streaks upon the surface. The atmospheric conditions may change the flowability of the concrete.

The choice of materials for forms is governed by the number of times it is possible to use them. Timber forms are best used in a structure where only a few repetitions can be made. Steel forms are economical when there is a large number of repetitions in the structure.

Some designers give plans of forms. This is of advantage in arranging construction joints in buildings where high stresses are used. The designer has many chances of saving in cost of formwork by slight modifications in his design. A careful study of formwork will have the tendency to eliminate expensive and difficult form building.

In removing the forms it must be remembered that wooden forms have a tendency to swell, while the concrete shrinks in the process of setting. For the easy removal of forms wedging strips are necessary. It is best to allow a drawing piece for each 10 or 12 ft. of form not free to move longitudinally, if the forms are to be removed in sections.

The question of forms is a building question and the method is optional with the builder as long as the forms fullfil their purpose and maintain the structure true to line and free from construction stresses. It is best, however, to give more complete specifications for formwork to relieve the builder from responsibility after the concrete is placed.

Fire Tests of Building Columns.—A detailed report of fire tests and fire-and-water tests on over 100 building columns has recently come from press. This report contains results of an investigation which has been conducted jointly during the past six years by the U. S. Bureau of Standards. The National Board of Fire Underwriters, and the Associated Factory Mutual Fire Insurance Companies. An edition of 5,000 copies of this report has now been published by the two last-named co-operating agencies and copies are available at what is practically the cost of publication. The report contains 389 pages and numerous illustrations, curves, and tables. Copies may be obtained for $2 per copy for the paper cover and $2.50 for cloth cover from the Underwriters Laboratories, 207 E. Ohio St., Chicago, Ill., or from the Associated Factory Mutual Fire Insurance Companies, 31 Milk St., Boston, Mass.

Index Numbers of Wholesale Prices 1913 to February, 1921

The accompanying tabulation shows the index numbers of wholesale prices by groups of commodities, as computed by the U. S. Bureau of Labor Statistics. The group of miscellaneous commodities includes such important articles as cottonseed meal and oil, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, laundry starch, tobacco, Manilla hemp, sisal, phosphate rock and wood pulp. The commodities, including the other groups, are as indicated by the title:

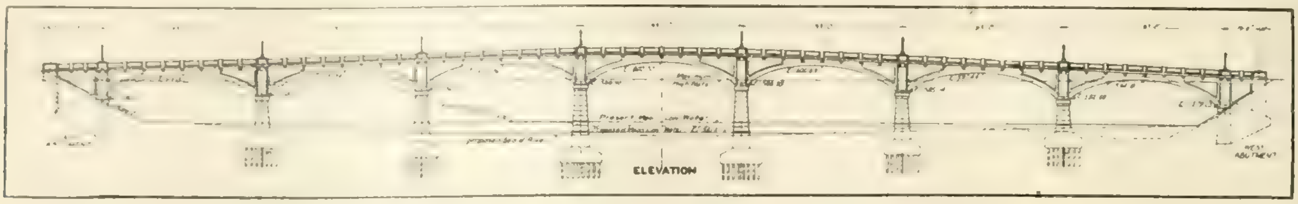
INDEX NUMBERS OF WHOLESALE PRICES IN SPECIFIED YEARS AND MONTHS, 1913 TO SEPTEMBER, 1920, BY GROUPS OF COMMODITIES.
(1913 = 100.)

Year and month.	Farm products.	Food, etc.	Cloths and clothing.	Fuel and lighting.	Metals and metal products.	Building materials.	Chemicals and drugs.	House furnishing goods.	Miscellaneous.	All commodities.
1913	100	100	100	100	100	100	100	100	100	100
Jan	97	99	100	103	107	100	101	100	100	100
April	97	96	100	98	102	101	101	100	98	98
July	101	102	100	99	98	101	99	100	101	100
Oct.	103	102	100	100	99	98	100	100	100	101
1914	103	103	98	96	87	97	101	99	99	100
Jan.	101	102	98	99	92	98	100	99	99	100
April	103	95	99	98	91	99	100	99	101	98
July	104	104	99	95	85	97	99	99	97	100
Oct.	103	107	97	93	83	96	105	99	96	99
1915	105	104	100	93	97	94	114	99	99	101
Jan.	102	106	96	93	83	94	103	99	100	99
April	107	105	99	89	91	94	102	99	99	100
July	108	104	99	90	102	93	108	99	98	101
Oct.	105	103	103	96	100	93	124	99	99	101
1916	122	126	128	119	148	101	159	115	120	124
Jan.	108	113	110	105	126	99	150	105	107	110
April	114	117	119	108	147	101	172	108	110	117
July	118	121	126	108	145	99	156	121	120	119
Oct.	136	140	138	133	151	101	150	124	132	134
1917	189	176	181	175	208	124	198	144	155	176
Jan.	148	150	161	176	183	106	159	132	138	151
April	181	182	169	184	208	111	170	139	149	172
July	199	181	187	192	257	132	198	152	153	186
Oct.	208	183	193	146	182	114	252	152	163	181
1918	220	189	239	163	181	151	221	196	193	196
Jan	207	187	211	157	174	136	232	161	178	185
Feb.	208	186	216	157	176	138	232	161	181	186
March ...	212	177	223	158	176	144	232	165	184	187
April	217	178	232	157	177	146	229	172	191	190
May	214	177	237	160	178	148	223	173	194	190
June	217	179	245	159	178	150	219	198	196	193
July	224	184	249	166	184	151	216	195	196	198
Aug	230	191	252	166	185	157	222	221	191	202
Sept.	237	199	255	167	184	159	220	226	194	207
Oct	224	201	257	167	187	158	218	226	196	204
Nov.	221	206	256	171	188	164	215	226	203	206
Dec.	222	210	250	171	184	164	195	227	204	206
1919	234	210	261	173	161	192	179	236	217	212
Jan.	222	207	234	170	172	161	191	218	212	203
Feb.	218	196	223	169	168	163	185	218	208	197
March ...	228	203	216	168	162	165	183	218	217	201
April	235	211	217	167	152	162	178	217	216	203
May	210	214	228	167	152	164	179	217	213	207
June	231	204	258	170	154	175	174	233	212	207
July	246	216	282	171	158	186	171	245	221	218
Aug.	243	227	304	175	165	208	172	259	225	226
Sept.	226	211	306	181	160	227	173	262	217	220
Oct.	230	211	313	181	161	231	174	264	220	223
Nov.	240	219	325	179	164	236	176	299	220	230
Dec.	244	234	335	181	169	253	179	303	229	238
1920	218	236	302	238	186	308	210	366	236	243
Jan	246	253	350	184	177	268	189	324	227	248
Feb.	237	244	356	187	189	300	197	329	227	249
March ...	239	246	356	192	192	324	205	329	230	253
April ...	246	270	353	213	195	311	212	331	238	265
May	244	287	347	235	193	341	215	329	246	272
June	243	279	335	246	190	337	218	362	247	269
July	236	268	317	252	191	333	217	362	243	262
Aug.	222	235	299	268	193	328	216	363	240	250
Sept.	210	223	278	284	192	318	222	371	229	242
Oct.	182	204	257	282	184	313	216	371	229	225
Nov.	165	195	234	258	170	274	207	369	220	207
Dec.	144	172	220	236	157	266	188	346	205	189
1921.										
Jan	136	162	208	228	[illegible]	[illegible]	182	283	190	177
Feb.	129	150	198	218	146	222	178	277	180	167

Construction Features of Black St. Bridge Piers, Hamilton, O.

Somewhat unusual methods are [illegible] by the Miami Conservancy District in constructing the piers for the Black St. bridge at Hamilton, O. The chief departure from ordinary procedure is the excavation of the pier foundations in the open by means of a drag line excavator. An interesting account of the substructure work is given in the Miami Conservancy Bulletin, from which the matter in this article is taken.

The foundations are on sand and gravel, more or less cemented with clay. Where in one or two cases clay strata were encountered, this material was removed and the foundations carried deeper. The maximum pressure below any pier occurs at one edge of the footing when one adjacent arch is loaded with the maximum live load. At Black St. this pressure is 3½ tons per square foot. With the entire bridge loaded this reduces to 2½ tons. To provide ample resistance to these pressures 130 to 150 piles are driven under each pier footing, spaced 3 ft. each way, the number depending on the width of footing and this in turn on the conditions at the particular pier. The piles are of 20-ft. length, driven 18 ft. into the sand and gravel and imbedded at the top 2 ft. in the concrete of the pier footing. The piers are carried down 12 to 16 ft. below the improved channel grade, so that the danger of scour reaching the pier bottom is remote. However, if it occurs, the penetration and spacing of the piles is such that the entire material immediately underlying a pier might be washed away, and the pier would still stand, supported by the piling. This supporting power was determined by actual test, as well as by observations on the piles under the last blows of the pile driver.

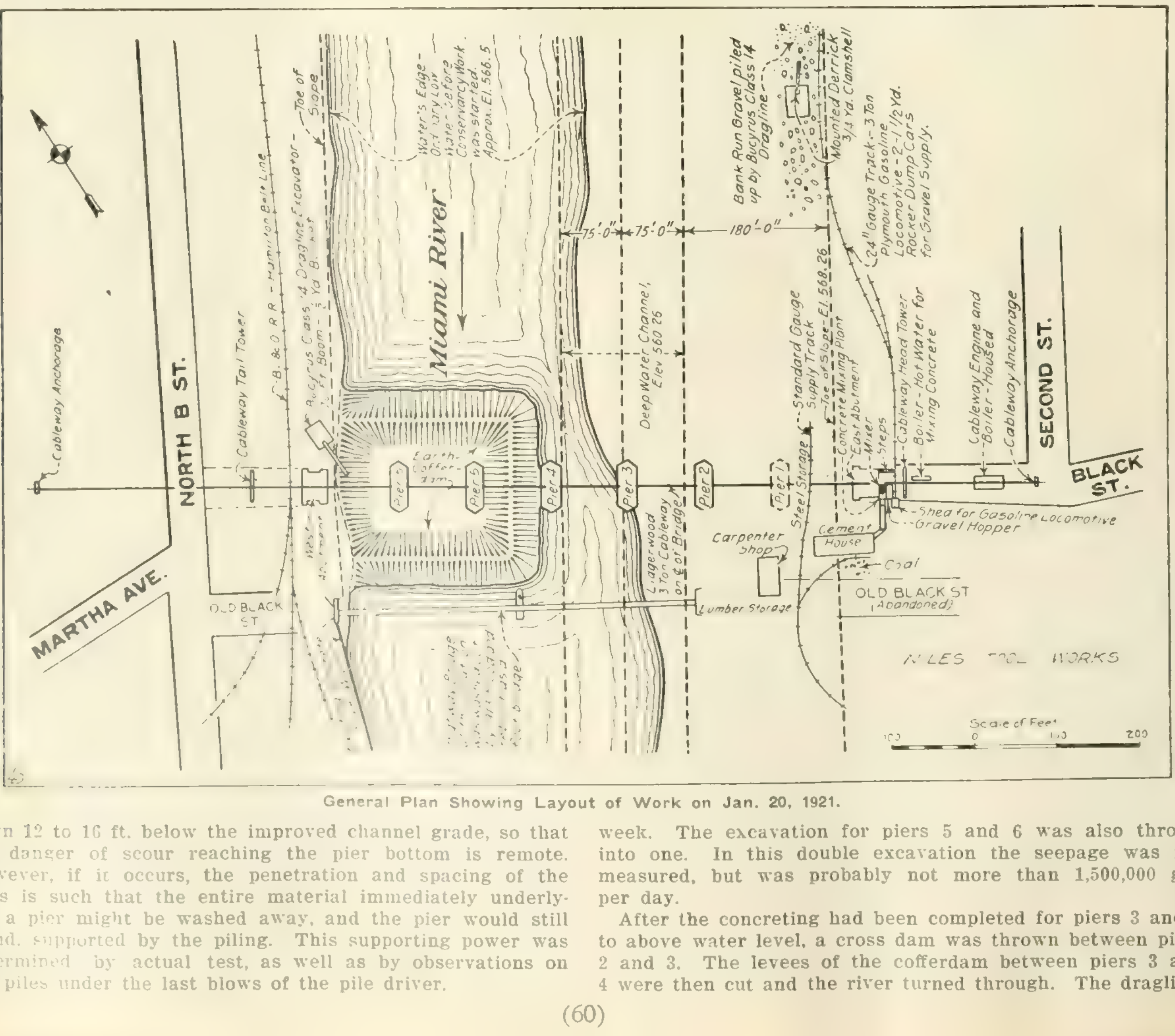


Elevation of Black Street Bridge at Hamilton, O., Showing Foundations.

The pile driver was a No. 3 Vulcan, with 1,800-lb. tup, cylinder 8 in. by 30 in. and total weight of 3,800 lb. Including the leads the total weight was 2½ to 3 tons. The pier footings vary from 21 ft. by 62 ft. to 24 ft. by 62 ft., according to the conditions encountered. They are reinforced transversely to distribute the heavy loads on the pier shafts evenly over the material below the footings. Bending effects in the shaft (due to unequal loading of the arches on each side) are resisted by light reinforcement near the shaft surfaces, this reinforcement also acting to prevent surface cracks. Horizontal grooves or "rustications" are carried around the surfaces of the shafts at regular intervals, to break up the monotony of appearance, acting in this respect like the courses in stone masonry.

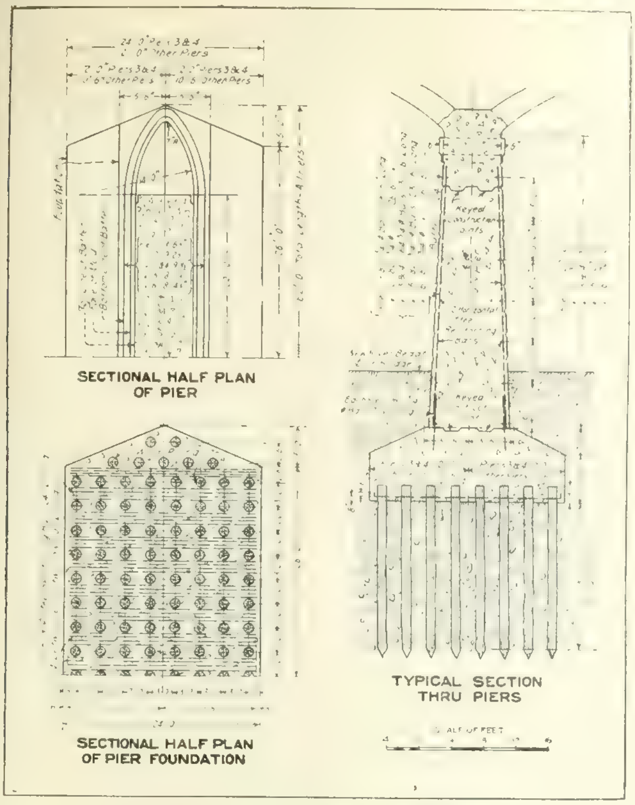
The method of open excavation for the piers has been used throughout, having been found so efficient on pier 3, the first pier excavated, that its use was immediately extended to pier 4, then to pier 2, then to piers 5 and 6. Pier 1 remains to be done. To save moving the pump outfit, the excavation for pier 3 was extended to include pier 4, and later pier 2, all in one large cofferdam. Seepage did not increase with these extensions, due to the silting up of the gravel of the cofferdam by river mud brought down in suspension during a rise in the river. The seepage with all three piers included was indeed scarcely greater than with pier 3 alone. The maximum was about 4,000,000 gal. per day, kept up for about a week. The excavation for piers 5 and 6 was also thrown into one. In this double excavation the seepage was not measured, but was probably not more than 1,500,000 gal. per day.

After the concreting had been completed for piers 3 and 4 to above water level, a cross dam was thrown between piers 2 and 3. The levees of the cofferdam between piers 3 and 4 were then cut and the river turned through. The dragline.


Cableway Anchorage
NORTH B ST.
Cableway Tail Tower
B. & O. R. R. - Hamilton Belt Line
Bucyrus Class 14 Dragline Excavator 1 Yd. Bucket
Toe of Slope
Water's Edge - Ordinary Low Water before Conservancy Work was started. Approx. El. 566.5
Miami River
Earth Cofferdam
Pier 6
Pier 5
Pier 4
Pier 3
Pier 2
Pier 1
75'-0"
75'-0"
180'-0"
Deep Water Channel, Elev. 560.26
Lidgerwood 3 Ton Cableway on ℄ of Bridge
Bank Run Gravel piled up by Bucyrus Class 14 Dragline
Mounted Derrick 3/4 Yd. Clamshell
24" Gauge Track - 3 Ton Plymouth Gasoline Locomotive - 2-1/2 Yd. Rocker Dump Cars for Gravel Supply
Standard Gauge Supply Track
Toe of Slope - El. 568.26
Concrete Mixing Plant
East Abutment
Mixer
Steps
Cableway Head Tower
Boiler - Hot Water for Mixing Concrete
Cableway Engine and Boiler - Housed
Cableway Anchorage
SECOND ST.
BLACK ST.
Shed for Gasoline Locomotive
Gravel Hopper
Steel Storage
Carpenter Shop
Cement House
Coal
Lumber Storage
OLD BLACK ST (Abandoned)
OLD BLACK ST
MARTHA AVE.
NILES TOOL WORKS
Scale of Feet
100 0 100 200

General Plan Showing Layout of Work on Jan. 20, 1921.

which did the work, was so maneuvered that while finishing it the machine stood on the west levee of the cofferdam and was thus able to proceed at once with the excavation for the next piers, 5 and 6, concrete work on pier 2 proceeding simultaneously. The seepage into the excavation at pier 2, after this had been isolated by the cross dam, was so slight that it was easily handled by a 6-in. pump working part time.


SECTIONAL HALF PLAN OF PIER

SECTIONAL HALF PLAN OF PIER FOUNDATION

TYPICAL SECTION THRU PIERS

Details of Black Street Bridge Pier.

The pumps in the triple excavation for piers 2, 3 and 4 were an 8-in. running constantly, and an 8-in. and 6-in. running part time. They handled the 4,000,000 gal. maximum without difficulty. The 6-in. pump had an 8-in. suction, one 8-in. had a 10-in. suction, the other a 12-in. All were electrically driven, with 30, 40 and 50-HP. motors, respectively. For piers 5 and 6 two of the above pumps were first used, superseded later by one 12-in. pump with 15-in. suction, driven by a 75-HP. motor. All the pumps were of the centrifugal type.

The pumps were set with a normal lift of 20 ft., increased at times to 22 or 23 ft. This, of course, was in the face of "conventional good form," which is to reduce the lift by setting the pumps as low as possible in the excavation, in order to avoid air leaks and loss of time in priming. The reason for the high setting was to avoid flooding the electric motors by the water rising in the excavation when the electric power shut down, a contingency occurring quite frequently. To meet this condition the pumps were set as high as possible and still lift the water. They worked well at the lift mentioned.

The dragline excavator used was a Class 14 Bucyrus, with 70-ft. boom and 1½-yd. bucket. It weighed 85 tons with the caterpillars, the latter with its drive mechanism weighing about 29 tons. The weight gave no trouble on the levees, the latter standing up perfectly under the load. The caterpillars were a distinct aid in maneuvering the machine around the cofferdams, and also have an advantage in enabling a quick "getaway" in case of high water. The machine was bought at second hand for $18,000.

The chief risk in using the method of open excavation is, of course, that high water may wash away the earth of the cofferdam levees. At Hamilton, on Nov. 22 and 23, this happened. The river rose 9 ft., and flowing mostly in a rather narrow channel between piers 3 and 4, acquired a high velocity. As a result first one corner and then all of the east side of the cofferdam enclosing piers 5 and 6 was washed away, including also about half of the north and south sides. Only the upper 10 ft. of the levees was affected, the material below remaining in place. Fortunately, the eroded material was not deposited within the cofferdam, so that after the levees had been rebuilt by the dragline and the water pumped out, it required only about two hours' hand work to clean up the excavation. The pump motors and loose material and equipment had been removed by the cableway before the break occurred. The delay due to the accident was just two weeks.

Gravel for the concrete is dug from the river bed by the

Excavation for Piers 5 and 6, Showing Levee Built Up From Material Taken Out by the Dragline.

dragline, and piled in a stock pile [illegible] a little north of the bridge site. An electrically operated stiffleg derrick, running on a 28-ft. gage railway, and equipped with a 34-ft. boom and a ¾ cu. yd. Owens clamshell bucket, loads this material into 1½-yd. Western rocker dump cars. These are transported to a storage hopper at the mixing plant by a 3-ton Plymouth gasoline locomotive on a 2-ft. gage track. The storage hopper, of 34 cu. yd. capacity, feeds the material in turn through chutes into the batch hopper of the mixer on the charging floor. The mixing plant is on the east bridge abutment. The oversize rock (above 6 in.), is screened out by a gridiron steel screen over the mouth of the storage hopper. The cement is wheeled from the cement house to the charging hopper by hand trucks. The mixer, a 1-yd. Smith, discharges directly into a bottom dump bucket, which stands in a pit directly below the cableway. The latter transports the bucket from the mixer to the work, where the concrete is discharged into a hopper, whence a chute takes it to the forms.

The cableway is a Lidgerwood of 5 tons capacity. The towers are 80 ft. high and 800 ft. apart, the hoist engines being housed on the east bank, with the 60 HP. boiler which feeds them. The cables comprise the main suspension cable, the fall line, the button line, and the endless cable which pulls the carriage. No trip line is used, the bucket being dumped by hand.

Tests made on the bank run gravel which is used show that the ratio of sand to gravel is about 1 to 2 at all times. For the mass concrete of the piers and abutments, therefore, no screening is necessary except to reject the oversize mentioned. The gravel is so clean that it requires no washing. For the bridge, arches, floors, etc., the gravel will be screened and proportioned as required.

The mix employed in the piers varies with the location. In the footings an approximate 1:3:6 ratio is used, 4 bags of cement being charged into a batch of concrete. The measuring is virtually done in the concrete bucket which transports the material to the forms, enough of the bank run gravel being run into the charging hopper, with the 4 bags of cement, to just fill the bucket after being mixed and discharged. For the stems of the piers 5 bags of cement are employed per bucket; and for the pier tops and for the last 8 or 10 ft. of the upstream pier nose, 6 bags are used.

Five of the six piers, the east abutment, and about half the west abutment, had been completed in January. Pier 1 still remained to be built.

Payment for Use of Small Tools on Cost Plus Work

In its annual report submitted at the recent meeting of the Associated General Contractors of America, the Committee on Methods recommended that payment for the use of small tools and appliances on cost plus work be fixed by either one of the following methods:

First Method: All tools, when brought upon the work, shall be listed, and, according to their condition, classed as follows:

New	= N.	100 per cent new
Good	= G.	75 per cent new
Fair	= F.	50 per cent new
Poor	= P.	20 per cent new
Valueless	= V.	0 per cent new

Upon completion of the work all tools should be listed and reclassified according to their condition. The decrease in percentage value multiplied by the market price of the respective tools, plus the value of lost tools, will then constitute the amount of payment due for small tools and appliances. This is developed as the tool charge in the A. G. C. cost plus contract.

Second Method: The expense of small tools and appliances has been found to vary from ½ of 1 per cent to 1½ of 1 per cent of the total cost of the work. Therefore, when it is necessary to predetermine a tool charge the amount may be fixed between these limits according to the character of the work.

Fabricating Shop Contracts in February.—The records of the Bridge Builders & Structural Society, from reports collected by its secretary, show that during the month of February, 1921, 25,600 tons of fabricated structural steel were contracted for throughout the United States, equivalent to 14 per cent of the entire capacity of the bridge and structural [illegible]

An Engineer at the Architectural Exhibit

Notorious is the divergence of view between architect and engineer, but the desirability of a better understanding will be denied only by such extremists as the esthete who feels that the practicalities are unworthy the consideration of an artist, and the extreme utilitarian who would measure the universe in terms of feet and kilowatts and dollars. We recommend, therefore, that our readers who are in Chicago visit the exhibit now in progress at the Art Institute, and which will continue until April 5th, with the definite purpose of trying to get somewhat of the architect's point of view.

Admitting that there may be fundamental differences between the mental types that are attracted to the two professions, and still more differences between those who attain pre-eminence in each, we believe that the greater part of the existing differences are due to the specialization of activities rather than to any natal endowment of individuals. But be these differences what or how they may, the facts remain that engineer and architect work in inseparable fields, that each is at times required to enter to some extent the field of the other, and that very often they must co-operate for a given end. They work for the same client—the man who is neither architect nor engineer—and this client demands structures that are efficient, safe, of reasonable cost, and beautiful. All four requirements cannot be fulfilled without a conjunction of the professions.

It will not do to say that so few people appreciate beauty that it is not worth while, for though a few only can analyze it, the majority feel it even when they cannot tell why they find this thing beautiful and that ugly.

Certainly the services of each of our building professions would be enhanced in value by a broadened view and an understanding and appreciation of each other's work.

There follow an engineering editor's observations and thoughts at the exhibition.

Some Deficiencies.—First as to what appears lacking: Considering the present housing shortage, the meagerness of the exhibits of small homes and apartment buildings is pathetic. Are the architects not sufficiently concerned to make an effort toward the stimulation of interest in this matter? We think that they have missed an opportunity.

The second lack to be noted is very different. We had expected to see many plans and details but comparatively few of either are shown, and so far as we observed no structural details whatever. Among the architects it was doubtless considered that the elevations, perspectives and photographs presented the subjects of greatest interest and importance; but we believe that the interest of the many non-architectural visitors to the exhibition would have been increased by the introduction of more floor plans and details both of structural and ornamental features.

These are the two main deficiencies noted. Of minor lacks, the most prominent to an engineer is the occasional omission of any statement of scale from a drawing: a small thing, but one not unworthy of remedy.

Predominant Style.—Only a few of the general impressions afforded by the exhibition can be mentioned. One of these is that there is an increase in the formality of styles. This is particularly noticeable in the landscape section, where almost all of the drawings depict somewhat formal arrangements. While being furthest from considering the beauty of art as superior to that of manure where the two are compared in their broader aspects, we believe that the formalism here observed is desirable because it is applied very largely to small grounds where there is insufficient space for any really natural appearance, and where attempts to that end are usually childish. Furthermore, the formalism in most of the exhibits is not extreme. In fact, we believe that it reaches a very happy stage in which the natural objects constituting the detail are arranged within a strictly limited area in a fashion orderly but not rigid.

Characteristics of the Drawings.—Another feature to be noted is the variety and beauty of style in which the drawings are rendered. Some are done in minute detail—others in a more or less impressionistic style. Some are in black or sepia—others in full color—and we may as well confess that it was the colored pictures which pleased the most. The titles, too, are frequently works of art. In engineering the ornate titles of a generation ago have vanished, and well that they have, but in architecture the desirability of the suggestion of beauty in all features of the plan still remains, and probably will remain.

Features of the Exhibit.—Clearly the most conspicuous single feature is the large white plaster model of the Bahai Temple—a proposed universal house of worship to be located at some point not far north of Chicago. In spite of all that has been claimed for this design as a worthy departure from previous architectural styles and as a possible forerunner of a new school, we are unable to find in it anything really startling.

To the architecturally lay mind it gives the impression of being wholly oriental in spite of its odd polygonal plan and what we suspect are certain departures from established principles. Beauty it unquestionably has. Structurally it presents inconveniences rather than great difficulties.

The one other large model of the exhibition is that of the Wrigley Building, Chicago.

House Models.—Two sets of smaller models are sure to catch the eye of every visitor. One of these comprises several residences of various types. Each house is shown in full color and is given a natural setting of lawn, trees, and shrubs. The work is so carefully done, and is carried out in so much detail that the effects are exceedingly pleasing.

The use of these expensive toys will probably be the first question of engineers and many others who see them: or they may even be condemned as not worth their cost without even the asking of the question. But here enters the necessity of appreciating another point of view. While architects, engineers, builders, skilled mechanics, and many others would have little need for them as supplements to paper plans and details, there are other people to whom models furnish the only means of understanding approximately how the finished structure is to look. The writer was once called upon by a hard-headed bank president to assist in laying out the grounds for a proposed residence. The banker stated that his land was nearly level, that it had a bank about 4 feet high at the rear, and that he thought a road could be run in from almost any point to a garage at the rear of the house. On visiting the site the 4-foot bank was found actually to be 9 feet, while the slope of the ground varied from 1 in 10 to 1 in 6. The owner had to concede that the bank was rather worse than he had thought, but he quite refused to admit that his land had any important slope; and he refused to believe the statements of both engineer and architect that he must either make a heavy cut at the rear of the propery or have a high and unsightly foundation with a long flight of steps at the front of his house until a level was run out from the proposed back line to the front, and a board nailed on a tree showing an 8-foot difference in elevation. He was never able to understand the architect's drawings, but finally a model of the house gave him something of an idea of how it was to look. Here was a man of attainments, clever in many ways, but so completely without mechanical sense that only as elementary a thing as a model could furnish the information he wanted.

The other set of models referred to is in the landscape section, and comprises a group of yards and gardens. We question whether these serve any very useful purpose. In the first place they are made to a scale so small that the presentation of the details so important in a minor landscape is very unsatisfactory in spite of some rather ingenious attempts to show them. One of the difficulties in this connection is that of the successful representation of foliage of different sorts; but by far the greatest obstacle is that land slopes presented in miniature do not appear true to fact. It would be too much to say that no landscape model is worth while, but it does seem that the opportunities for its practical use are rare.

The Importance of View.—Notable among the architectural drawings are those in the competition of the Chicago Architectural Club for the design of its own house. All of these treat of the environment and approach to the building as well as of the structure itself, thus giving conspicuous recognition to the frequently overlooked fact that it is useless to place a beautiful building or feature of a building where it cannot be seen to advantage.

Numerous industrial and commercial buildings are shown, and some of these we think show admirably how such structures may be given an appropriate beauty and dignity without masquerading or belittling their true purpose. As useful structures might have been designed by engineers alone, but the attractiveness which can scarcely be missed by even the common workman, can only come from true architectural knowledge.

Not All Is Pleasing or Consistent.—A general inspection of the exhibits inevitably raises questions. Why, for instance, make a public library look like a tomb? Or why put a set of figures in medieval costume in the picture of a structure for twentieth century use? We believe that the architects as well as the engineers need broadening.

Surface Treatment of Concrete on Bloor St. Viaduct Toronto, Ont.

Three years' exposure has brought out no defects in the surface finish on the concrete piers and hand rail of the Bloor St. viaduct, at Toronto, according to a paper presented Feb. 17 before the Toronto Branch of the Engineering Institute of Canada, by T. Truman Black, Construction Engineer, Toronto. Mr. Black gives the following details regarding the surface treatment methods:

On the piers as soon as the forms were removed the surface was smoothed up, either by wooden trowel if the concrete were still soft, or by carborundum brick if the concrete were hard. The surface was then thoroughly washed with a hose. While wet the surface was floated with mortar with a wooden trowel and left for a short time; then another man followed with a steel trowel and scraped all the mortar possible from the surface. This left the concrete surface clear of mortar, while the small holes were filled. The surface was then gone over with a white-wash brush dipped in a wash of cement and water, and a clean waterproof surface was the result. After three years this surface is free from hair cracks or other defects.

In the hand rail the conditions were different. The specifications stated that the surface should be so treated that the larger aggregate should be exposed but not disturbed. This aggregate was 1-in. red granite. This result was obtained by the following means:

The forms were so built that a small part could be removed at a time. The time for removal was chosen when the concrete had to some extent taken its final set, though still very fragile. A small portion of the form was removed the mass of the hand rail being supported by the remainder of the form. A laborer with a wire brush immediately went over the surface and brushed out the surface mortar for about ¼ in. from between the stones. If the concrete were soft, a fine brush would do the work; and as the concrete got harder, stiffer brushes were used. The action of the brushing seemed to speed up the setting, and the surface was much harder when the brushing was completed, though it had taken only a few minutes. The whole surface was treated in this manner. After all the surface had been stripped and brushed, men went over it again with water and scrubbing brushes. This removed part of the gray mortar which was sticking to the exposed granite. About six hours later the entire surface was washed with a dilute solution of muriatic acid, which removed all the cement from the exposed granite and left the surface clean. After the acid bath the surface was flushed with water until all the acid was washed away.

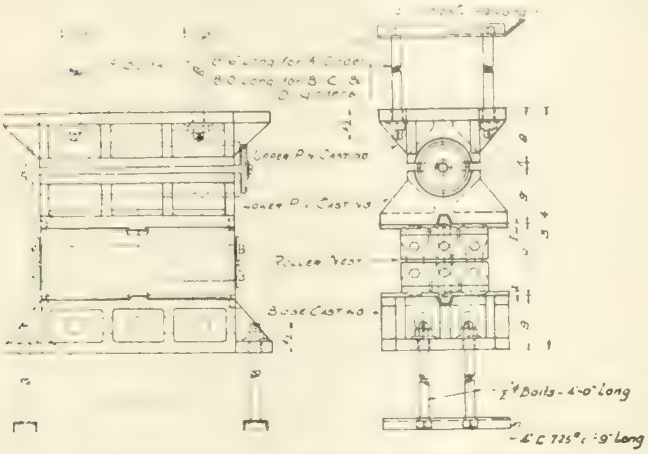
In the surfacing of the railing it was noticed that the brushing made the surface concrete much harder than that which was allowed to take its usual time in the forms—a sort of case hardening. After three years the railing does not show any defects, and boys have not been able to pry any of the exposed granite from the surface.

Waterproofing Materials for Building Stones.—The study of colorless waterproofing materials is being continued by the U. S. Bureau of Standards to determine the value and relative merits of different compounds recommended for the purpose of waterproofing stone. Specimens of Indiana limestone treated with various proprietary materials have been exposed to the weather for a period of three months. Absorption tests lasting for 30 minutes conducted at the end of each month indicate that some of the materials are more effective than others. The slight increase in absorption of the specimens as the period of exposure lengthens indicates that there is a gradual deterioration of the protection afforded by the treatment. By continuing the exposure over a considerable length of time, it is believed that the period of effectiveness may be ascertained.

Expansion Rollers Under Large Concrete Girders in Roosevelt Road Viaduct, Chicago

By M. GRODSKY and F. W. SHAW.

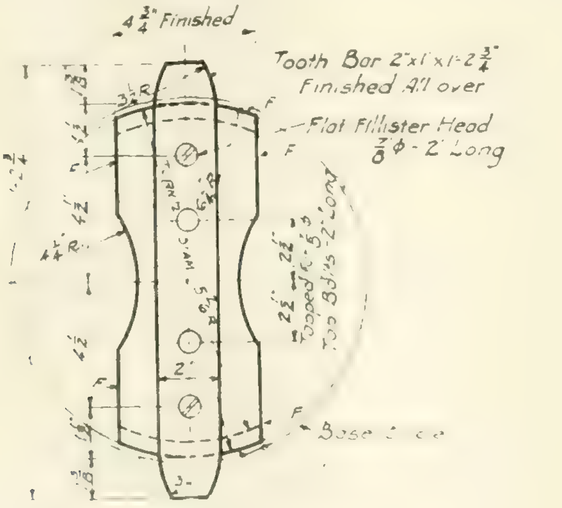
In the design of the Roosevelt Road Viaduct in Chicago (east of the Chicago River) a number of unusual features were encountered. The viaduct is a reinforced concrete structure consisting of four lines of longitudinal girders carried on columns. The structure is entirely monolithic between expansion joints and it was therefore necessary to take careful account of the stresses in the columns due to changes in the lengths of the girders caused by variations in temperature.



Front and End Elevation of Roller Bearings.

In all sections of the viaduct except one it was possible to do this by reinforcing the columns with vertical steel. The exception was the section between the expansion joint at South Wells St. (bent 37) and the east abutment of the bascule bridge spanning the South Branch of the Chicago River (bent 39). This section consists of two spans resting on two columns and on a pilaster at the east abutment. The span lengths vary from 55 ft. to 75 ft. on the south girders and from 64 ft. to 65 ft. on the north girders.

The Chicago Surface Lines' requirement of a special manganese steel casting to connect the 7 in. rail on the viaduct with the 9-in. rail on the bridge made it necessary to use a deeper trough on the viaduct in this section, thereby considerably increasing the dead load. The live load on this section was increased due to a provision made for a double cross-over for street cars from Wells street to Roosevelt road. In addition to this there is an increase due to congestion of traffic on this section when the bascule bridge across the river is open.

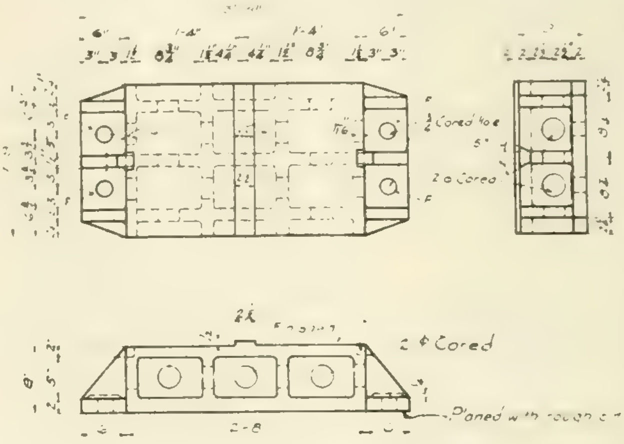


Detail of Cast Steel Roller.

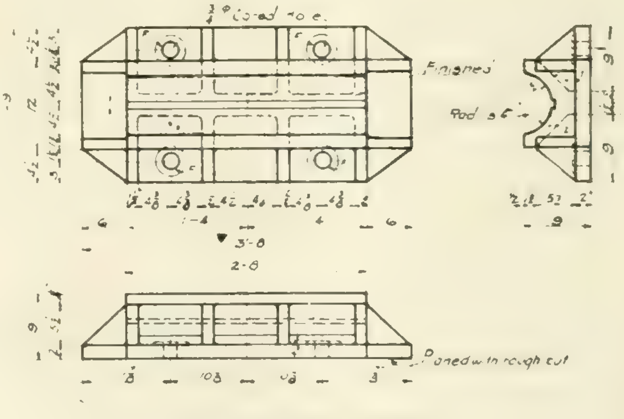
The layout of railroad tracks under the viaduct made it necessary that the columns supporting this section be skewed with respect to the center line of the viaduct. The fact that the columns are skewed causes them to be stiffer and therefore take more moment, without increasing their strength. This combination of long spans, heavy dead and live loads and stiffer columns made the stresses in those columns higher than was typical in other sections of the viaduct.

The west ends of the girders resting on the abutment were practically fixed against sliding. All movements caused by changes in the lengths of girders due to temperature would originate from the abutment. This would bring a large deflection to the columns at the expansion joint at the east ends of the girders, causing heavy stresses on the columns, especially as they are stiffer than usual. The stresses due to direct loads added to those caused by changes in temperature would overstress the column.

This condition led to the investigation of a number of means by which the ends of the girders resting on the pilasters at the east abutment could be allowed to slide as the girders changed in length with variations of temperature. At first pilasters separated by expansion joints from the rest of the abutment were tried. By this means a two-span bent with three columns was obtained. But the maximum available thickness of the separate pilasters was 18 in., and the dead and live load bending alone would overstress these columns.



· DETAIL OF BASE CASTING ·
(Cast Steel)-2 Required

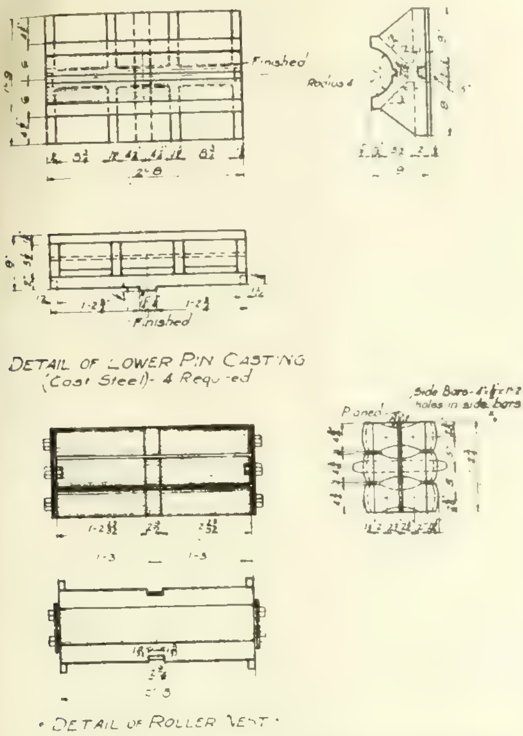


· DETAIL OF UPPER PIN CASTING ·
(Cast Steel)-4 Required

Details of Base and Upper Pin Castings.

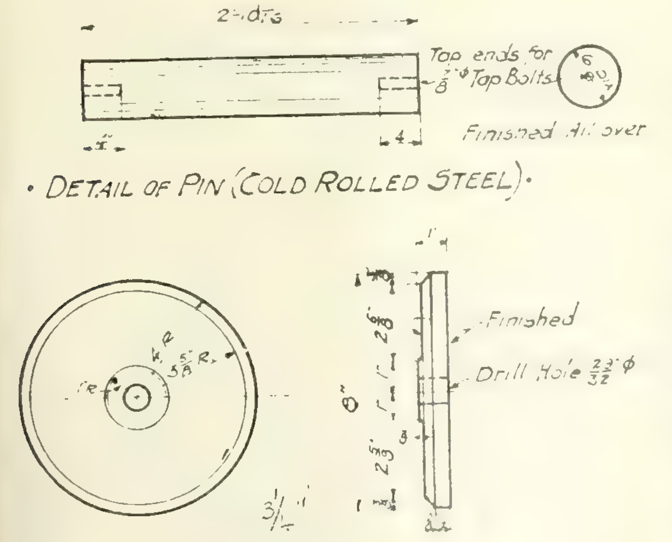
Then a means to provide sliding on the abutment was tried. In investigating the possibility of sliding and a method of providing for it the following difficulties were encountered. The reaction on the pilaster due to live and dead loads amounted to over 600,000 lb. The horizontal force developed by the temperature changes increased by the force due to the rigidity of the columns and girders under dead and live loads amounted to only approximately 80,000 lb. In other words, the horizontal force causing or tending to cause sliding is only 80,000 lb. The vertical or normal pressure is 600,000 lb. and therefore the maximum coefficient of friction which could be allowed and still have the girder slide is $\frac{80,000}{600,000} = .133$. This meant that more than ordinary care had to be taken in the choice and design of an end bearing for th [illegible]

Sliding of a phosphor bronze plate on a cast iron plate was considered. But it was impossible to insure a coefficient of friction less than .133 without more than the usual amount of inspection and maintenance. The angular deflection of the abutment end of the girders would cause uneven bearing of the plates, thereby making it impossible to keep them properly lubricated.


Finished
Radius 4
Finished
DETAIL OF LOWER PIN CASTING (Cast Steel)- 4 Required
Planed
Side Bars
holes in side bars drilled to
DETAIL OF ROLLER NEST

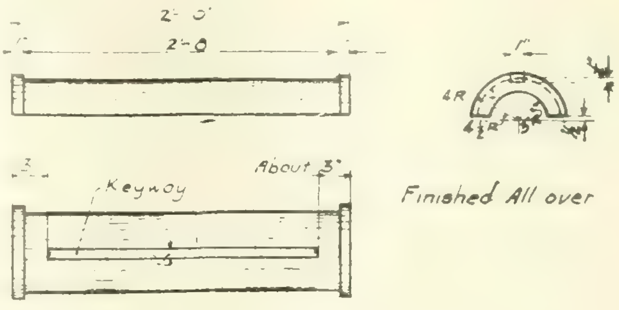
Details of Lower Pin Casting and Roller Nest.

After a careful study the following arrangement was adopted. The concrete girder rests on an upper pin casting and is fastened to it by four 1½ in. bolts. The bearing is distributed in the girders by a gullage of two layers of 7 in. I-beams. The angular defection of the girders is taken care of by the upper pin casting rotating about a 6-in. steel pin set in a phosphor bronze split bushing, one-half of which is in the upper pin casting and one-half in the lower pin casting. The lower pin castings rest on the roller. Sliding is provided for by a nest of three 12-in. segmental rollers which are geared to the lower pin casting above and the bed casting below by means of a tooth-bar. The bed casting transmits the load to the pilaster through a grillage of 7-in. I-beams. The bed casting is held in place by four 1½-in. anchor bolts


Tap ends for 5/8" Tap Bolts
Finished All over
DETAIL OF PIN (COLD ROLLED STEEL)
Finished
Drill Hole 23/32 φ

Details of Pin and Pin Cap.

Great care had to be taken to insure proper action of the rollers with a small amount of maintenance. For this reason the castings were set in pockets at the ends of the girders; the sides of the pockets or casting houses being 6-in. concrete walls. There are two doors in each casting house, one on each side of the girder, to allow for inspection and cleaning of castings whenever necessary.



Detail of One-half of Split Bushing.

The estimated cost of each set of expansion castings, based on prices current in October, 1920, was $6,600.

Labor's Share in Building Costs

Of each $100 worth of building work normally done in the Philadelphia District, labor received $44, according to a report of the subcommittee on Wages and Building Costs, submitted at the Housing Conference at Philadelphia, Feb. 15-18. The above figure is based on the cost of an imaginary composite building and was arrived at by taking actual cost figures on seven different types of buildings, including ordinary 2-story brick dwelling (row type), detached residence, reinforced concrete factory building, slow burning construction, warehouse building, steel frame office building, fireproof and wood floor school buildings with stone walls, and brick apartment house. The relative importance of these different types of building in determining the figures for the composite whole were determined by reference to the published lists of building permits and similar statistics as furnished by the F. W. Dodge Co., so that the result as given represents as nearly as possible the exact relative importance of the various items in the make-up of the total volume of building business transacted in this territory, the Philadelphia District. The analysis in percentages of cost of a composite building, showing average values of various items for each $100 worth of building work normally done in Philadelphia District follows:

Labor:		
All skilled labor and supervision on the building, including also stone cutting and shop work on sheet metal and millwork only	$27.55	
Unskilled labor as above	9.44	
Office, estimating, general supervision and engineering salaries	5.60	
Liability insurance	1.41	
Total labor (no manufacturing except as stated)...		$ 44.00
Materials:		
Lumber for millwork, concrete forms and structure delivered at site	$ 8.86	
Bricks—delivered at site	6.10	
Steel—structural, miscellaneous and reinforcement, delivered at site	5.93	
Boilers, heaters, piping, etc., for heating	3.05	
Plumbing fixtures, piping, etc	2.76	
Cement, f. o. b. cars	2.60	
Hardware, nails and similar miscellaneous materials	1.78	
Sand, delivered to site	1.69	
Electric fixtures, conduit wire, etc	1.60	
Stone, slag and pebbles for concrete	1.49	
Sprinklers and fire protection apparatus and minor unclassified items	1.04	
Building stone	.90	
Paint	.76	
Roofing and sheet metal materials	.70	
Plastering materials (no sand)	.65	
Lathing materials	.65	
Steel sash, etc., delivered to site	.50	
Lime (no plaster)	.45	
Glass	.40	
Cut stone (materials) and terra cotta	.38	
Elevators (delivered to site)	.28	
Mechanical equipment, cranes, etc	.21	
Tile and marble (materials only)	.10	
		42.88
Overhead Expense and Profit:		
Office rent, taxes, interest, depreciation of equipment, general expense and overhead (not wages)		5.80
Net compensation of all sub-contractors (assumed as doing 65 per cent of the work direct)		3.90
Net compensation of general contractor (assumed as doing 35 per cent of the work direct and supervising the balance)		3.42
		$100.00

Proposed Revised Constitution and By-Laws of Am. Soc. C. E.

The special committee of the American Society of Civil Engineers, known as the "Committee on Referred Amendments," which for the past 8 months has been preparing a new constitution and by-laws for the society, has submitted a revised constitution to the Board of Directors. This document will be in order for discussion at the business meeting to be held during the next annual convention which occurs at Houston, Tex., on April 27.

In its report, dated Feb. 17, which accompanied the new constitution, the committee states:

> ....We have felt that the experience of past attempts to revise the constitution has demonstrated the necessity for the presentation of a complete and co-ordinated draft of the entire instrument and a division or separation of those provisions which may be called fundamental and primary in a classification called "Constitution," while the detailed and more administrative provisions have been assigned to a classication termed "By-Laws," capable of amendment and revision and adaptation to changing circumstances with more facility than is necessary or desirable in the case of the fundamental elements of the society's organization.
>
> The committee, while it has redrafted the constitution as a whole, has endeavored to make as few changes in the substance of the document as was consistent with the attainment of the general purposes which the committee considered desirable. . . . . Certain changes were felt to be necessary in order to conform the regulations of the society to the requirements of the statute law.
>
> Under the provisions of the present constitution it would not be practicable to present this matter to the vote of the society in time to have it acted upon this year unless the procedure was adopted of proposing the new constitution as a constitutional amendment at least 60 days prior to the annual convention now set for April 27, 1921. The committee, therefore, as individuals, have taken the liberty of proposing the draft of the constitution approved by them as an amendment to the constitution to be presented to and acted upon in the manner provided by Article IX of the constitution, at the annual convention, for the reason that the next regular meeting of the board of direction taking place in March, is at a date too late to enable any action of the board of direction respecting the amendment to be presented by way of proposed constitutional amendment at the annual convention.
>
> The committee feels that the result attained by the committee, while of course, it will not be entirely satisfactory to every member of the society, is, nevertheless, in accord with and a step towards the realization of the wishes of the great majority of the society's membership and that it is, practically speaking, as close an approximation to a harmonizing of the many divergent suggestions and opinions as can be realized at this time. In arriving at this result, the committee has given most thorough consideration to alternative suggestions with regard particularly to the nomination and selection of the officers of the society and to subdivisions of the society for that purpose. In recommending the plan adopted it has, after a consideration extending over many months, felt that the disadvantages of other methods that have been proposed, some of which were originally favored by members of the committee, outweighed their advantages as compared with the plan adopted by the committee and herewith presented.

The principal reasons for the several changes and modifications in the old constitution, as well as an outline of the scope of the proposed new draft, are indicated briefly in a statement submitted by the committee with its report. In the statement the committee says:

> In many instances the committee has made changes in the language of provisions of the constitution, in the interest of brevity or simplicity. These changes, except where indicated hereafter, do not make radical changes in the substance of the society's organization or methods of administration. It has been the committee's aim to make as few changes as possible in respect to comparatively minor features of the organization about which there might be difference of opinion, with the hope that this will enable the more important changes to be effected.
>
> These important changes the committee considers to be (1) a form of government that would be more directly representative of the membership body as a whole; (2) a method of nomination and election of officers that would bring the entire membership into participation and avoid as far as possible the probability of the preponderating influence of any locality; and (3) by-laws governing details of administration which can be changed and adapted to changing conditions with comparative facility.

The comments of the committee on the various provisions of the proposed new constitution and by-laws follow:

Constitution.

ARTICLE I. Name, Location and Object.—The matters set forth in this article are required by law to be set forth in the Certificate of Incorporation and are so set forth. Their inclusion here is simply in conformity to usage and not because of any legal requiremnt. The statement of the objects is in the precise language of the Certificate of Incorporation, omitting one word.

Many excellent suggestions as to phraseology of statement of the objects of the society have been received and considered by the committee, but it seemed obvious that any language differing from that in the statement in the Certificate of Incorporation, could only limit and could not extend the purposes or powers of the society.

ARTICLE II. Membership.—The only change in Section 1 is the substitution of the title "Affiliates" for the title "Associates." This is to obviate confusion, particularly in the mind of the public, as to the difference between "Associates" and "Associate Members." The title "Affiliates" has been therefore used throughout the revision in place of the title "Associates."

Section 2 is unchanged except the last sentence. The last sentence as at present written is the clause recommended both by the 1917 Committee on Constitution and by the Committee on Development. [This last sentence in the new constitution is: "Responsible charge in engineering teaching may be construed as responsible charge of work as required by the constitution."]

Section 9.—This section is to cover the recommendation made by the Board of Direction April 19, 1920, pursuant to a report of the committee which studied and reported on the subject. [This section follows: "Student Chapters with a limited use of privileges or facilities of the society may be authorized by the Board of Direction as provided in by-laws or other regulation for their recognition and affiliation; but the members of such chapters shall not therefore be deemed for any purpose to be members of the society, and no permanent or irrevocable privilege shall thus be conferred."]

ARTICLE III. Admissions and Expulsions.—This has been reduced from the eight sections in the present constitution to three sections by the transfer of details to by-laws and by slightly changing the language in what is now Section 1. There is no radical change in the result thus achieved.

The committee believes that some changes in the procedure regarding expulsion should be made at an early date. The suggestions received varied so much and the matter is of such nature that wide differences of opinion are inevitable. It seemed, therefore, that for the present it would be better that 99 guilty should be saved rather than one innocent should be punished, and that any change in this article should be made the subject of a separate amendment which could be voted upon independently of the proposed new constitution and by-laws.

ARTICLE IV. Dues.—Sections 1, 2 and 3 are in substance unchanged with the exception that it is now clearly provided that foreign members, to wit, members outside of North America, shall not be subjected to the increased dues of members resident in District No. 1.

The substance of the provisions respecting the times for the payment of dues and discipline have been transferred to the by-laws.

ARTICLE V. Officers.—As proposed, the total number of members of the Board of Direction will be reduced from 30 as at present to 25, consisting of the president, four vice-presidents, 18 directors and 2 past-presidents. The secretary is not made ex-officio a member of the board, but may be appointed by the board either from its own members or from other corporate members. The New York State law prescribes that all directors must be elected by the corporate members, and the committee has felt that it was more desirable to have a secretary appointed by the Board of Direction. The elimination of the treasurer from the board is in the interest of equality of representation of the different geographical districts, it being felt that probably the treasurer would be, for reasons of efficiency, a resident of District No. 1. The practice of having the secretary and the treasurer appointed by the Board of Direction is, as far as your committee can ascertain, followed by all organizations similar to this society.

ARTICLE VI. Management. Sec. 1 is a general statement of the powers and duties of the Board of Direction, leaving the details to the by-laws which, however, do not make any substantial change in the duties as at present provided.

The number required for a quorum of the Board of Direction has been increased, both because it was deemed better to require a larger attendance and also to comply with the statutory requirement that at least one-third of the board should be necessary to constitute a quorum.

Section 3 authorizes an Executive Committee such as has existed for the past several years without express constitutional authority. The Executive Committee is the creature of the entire board, and is subject to its will and may exercise only such authority as may be delegated to it by the Board of Direction. It therefore continues the purpose of a representative administration of the society's affairs, as compared with a condition where said affairs would be managed by those directors more likely to attend meetings because of their proximity to the meeting place, which of course has a tendency to give greater control of the management to those directors residing in the vicinity of the place of meeting.

ARTICLE VII. Nomination and Election of Officers.—This article provides a wholly new method of nominating and electing officers. In substance it provides for electing official nominees by direct primaries, and for as nearly equal a representation of the different geographical districts on the Board of Direction as may be, in proportion to their corporate membership.

A great number of suggestions as to procedure in the nomination and election of officers was received and considered by the committee. The great majority had in view the same purposes as those intended by the amendment now proposed, but differed in details of the machinery to be used for effecting those purposes. Among others, various forms of the plan of using local sections as a unit for nominations and requiring the allocation of the membership to the existing local sections and to new local sections to be formed, was most thoroughly considered.

Many advantages might be pointed out in several of the plans that were considered by the committee, but as to each plan there were counterbalancing disadvantages which in the opinion of your committee might render it less generally acceptable to the corporate membership than the one now proposed. The plan proposed is democratic, and would seem to be calculated to remove the possibility of any undue preponderating influence by any part of the corporate membership, and also to enable each corporate member more directly than by any other method to express his wishes and policy with respect to the administration of the society's affairs. On the other hand, the physical machinery by which the will of the corporate membership is ascertained is concentrated at one point, thus avoiding the expense and the delays and mishaps that might be incident to appointing special officers over various districts to act and make reports to headquarters.

In this connection attention is called to the requirement of the New York State law that each member of the society has the right to vote for all of the directors, so that members resident, for example, in California have the legal right, of which they cannot be deprived, to vote for and elect who shall be their trustees, although they be nominated from Illinois or any other state.

ARTICLE IX. Local Sections.—The present constitution does not recognize the local sections, and it is felt that they should be definitely provided for. On the other hand, the committee has not deemed it wise to establish a rigid set of regulations or constitutions for the local sections, some of which have been functioning under their own rules for a considerable period. Different sections may have differing conditions which the members in those sections are in a position to call to the attention of the Board of Direction, and the society is protected by the requirement that their constitution must be acceptable to the Board of Direction.

In practice, where a local section is about to be formed, someone there usually writes to the secretary for copies of the constitution and by-laws of other local sections. The secretary then forwards a copy of some constitution and by-laws for local sections that has proven satisfactory in practice. The proposed local section then, after examination, is in a position to suggest modifications to meet its own local needs and may also suggest very desirable general improvements.

ARTICLE X. Amendments.—The only substantial change is that requiring 30 corporate members to propose an amendment to the constitution, instead of five. This seems more in keeping with the present large membership and prevents the presentation of amendments which will have but very little support and for which there is no substantial request.

By-Laws.

ARTICLE I. Election of Members.—There is no change made in the present method of electing members.

ARTICLE III. Management.—The only important changes made here are: (1) the transfer of the duties of the Finance Committee to the Executive Committee; (2) provision for the appointment of a secretary and treasurer by the Board of Direction without the requirement in the constitution that they be members of the Board of Direction, although it is within the power of the Board of Direction to select their own members for these offices. The reasons for the suggestion as to the secretary and treasurer have been mentioned in the comment on Article V of the constitution.

ARTICLE IV. Committees.—The substantial changes here are: (1) the abolition of the Finance Committee and the formation of an Executive Committee which has been commented on heretofore; (2) the formation of a Public Relations Committee; and (3) the abandonment of the elaborate provisions for the appointment of special committees by a vote of the membership, and giving to the Board of Direction general authority to appoint special committees.

Concerning the Public Relations Committee, the provisions suggested in Section 3 give very broad general powers of investigation and recommendation to such a committee and provide for a distributed representative personnel. The elaborate method provided in the constitution for the election of special committees by the membership is so cumbersome that in practice it has become obsolete. The proposed method is in accordance with that usually employed in other societies, and that in fact heretofore used by this society.

ARTICLE V. Student Chapters.—This provision is in accordance with the recommendations of the Committee on Student Branches approved by the Board of Direction, April 19, 1920.

ARTICLE VI. Meetings.—The new matter herein provides an order of business which is that customarily used at the respective meetings. It is provided in the constitution that the annual convention or annual meeting may, despite this provision, arrange its own order of business if it sees fit.

The Committee on Referred Amendments consists of P. Junkersfeld, chairman; P. H. Norcross, secretary; A. Stuart Baldwin, A. D. Butler, J. F. Coleman, L. R. Ash, L. L. Hidinger, E. J. Schneider.

Construction Workers' Severity Rate Reduced 75 Per Cent.—A comparison of the accident records of Fred T. Ley & Company, Inc., general contractors, of Springfield, Mass., for the year July 1, 1919, to July 1, 1920, and the four months' period from July 1, 1920, to October 1, 1920, shows a decrease of 75 per cent in the severity rate, and more than one-third in the frequency rate. Included in the total number of days lost from July 1, 1919, to July 1, 1920, were 30,000 days entered for five fatal accidents. There were no fatal accidents in the four months' period. The following table reprinted from the March 21st National Safety News gives the Ley Company's report:

	Period July 1, 1919, to July 1, 1920.	Period July 1, 1920, to Oct. 1, 1920
(1) Average number of employes	3,341	3,055
(2) Total number of hours actually worked by all employes	10,024,782	2,291,276
(3) Number of accidents causing lost time beyond day or shift during which injury was received	519	82
(4) Number of days lost because of accidents	33,057	1,932
(5) Frequency rate. Number of accidents per 1,000,000 hours worked	51.8	35.8
(6) Severity rate. Number of days lost per 1,000 hours worked	3.29	.84 (Decrease 75%)

Food Cost Falls 9 Per Cent in February.—Food costs of the average family declined 9 per cent in February as compared with January, the Bureau of Labor Statistics announced on March 18. All of forty-four articles reported, except hens, decreased in price, the figures showing hens having increased less than five-tenths of 1 per cent. The greatest decrease in average family expenditure was in Buffalo and Butte, Mont., at 11 per cent for the month. In Detroit, Louisville, Memphis, Rochester and Savannah the decrease was 10 per cent. In nineteen other cities, including Chicago and New York, the decrease was 9 per cent. At Springfield, Ill., it was 8 per cent. The lowest was at Seattle—4 per cent.

Ingenious Transverse Expansion Joint for Reinforced Concrete Building

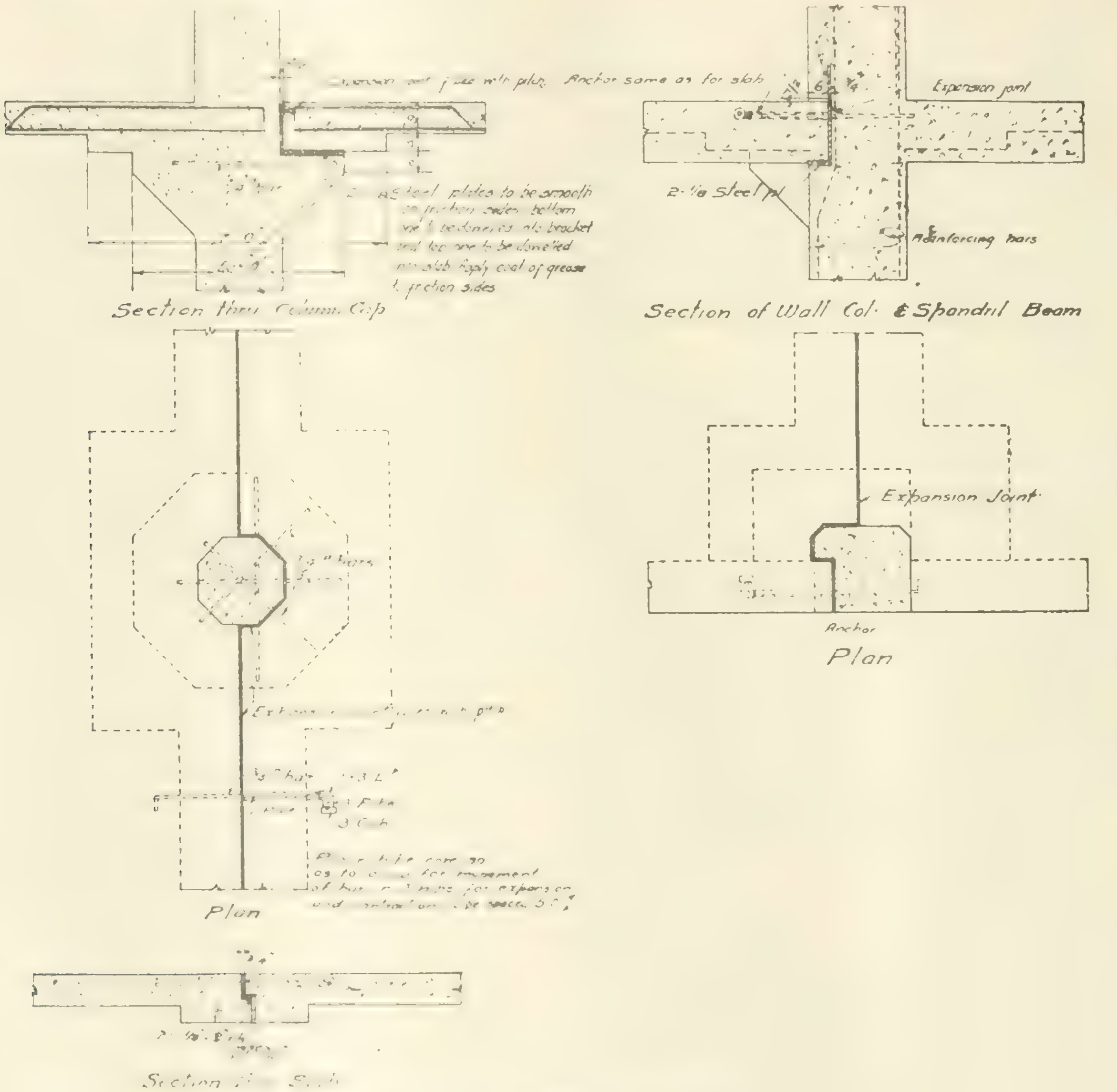
Interesting structural features, encountered in an addition built for the Dunlap Tire Co.'s plant in Toronto, Ont., are described in the Canadian Engineer of March 3, 1921. The building is a four-story reinforced concrete, skeleton type, 82 ft. 6 in. by 402 ft. 6 in. The walls are 9 in. spandrel carried on concrete wall girders. The live load on all floors is 250 lb. per square foot. The floor construction is a four way flat-slab with 20 ft. by 20 ft. panels, designed according to the Toronto code. The slab is 9 in. thick; the drop panel is 7 ft. by 7 ft. by 5 in. thick; the cap is 4 ft. 6 in. in diameter. The interior columns are octagonal reinforced with spirals. The exterior columns are rectangular. They have ⅞ in. by 5¾ in. recesses to hold the brick spandrel walls. The column core is covered with 2 in. fireproofiing. The foundation is of the spread type; the footings are reinforced with four layers of steel; the bottom of the footing is 6 ft. below grade.

A 4 ft. by 6 ft. tunnel carrying piping runs part way under the building. It also carries the drainage gutter, having cross-troughs discharge into it.

Provision for future extension was made by designing the wall girders of L-shape, leaving a notch in the girders 5 in. wide and 14 in. deep. At columns the reinforcing steel was left projecting.

An expansion joint was carried across the building 160 ft. from one end, making two independent units. Sliding was provided by two ⅛ in. steel plates greased. The joint is ¾ in. wide and filled with pitch. Anchors were placed every 5 ft. to limit the separation between the two parts of the building. The accompanying details show the expansion joint of the slab, and at the interior and exterior columns.

The concrete was of a 1:2:4 mix. The reinforcing steel was structural grade plain bars. Concreting was done during freezing weather. The materials were heated; the poured parts covered with canvas and heated with salamanders.


Anchor same as for slab
Expansion joint
2-⅛ Steel pl
Reinforcing bars
Steel plates to be smooth on friction sides bottom ... bracket ... slab apply coat of grease ... friction sides
Expansion Joint
Anchor

Section thru Column Cap

Section of Wall Col. & Spandril Beam

Plan

Plan

Section ... Slab

Details of Expansion Joint Across Building.

Circular on the Physical Properties of Materials.—During the past few years, the U. S. Bureau of Standards has received numerous requests for information regarding the physical properties of materials, principally ferrous and non-ferrous metals and alloys. Some time ago, the compilation of most of the available data on this subject was undertaken. The tables which were compiled as a result of this work were issued to a limited number of government establishments in mimeographed form. As they seemed to fill a very real need, it was deemed advisable to issue them in the form of a Bureau publication, and Circular No. 101 is the outcome of this work. The circular aims to present in readily accessible form the best available data on the strength and related properties of materials. Among those treated are iron, carbon steel, alloy steels, wire and wire rope, semi-steel, aluminum, copper, miscellaneous metals and other alloys, rope, rubber, leather, and wood. The tensile strength, proportional limit, percentage elongation in 2 in., percentage reduction of area, Brinell and scleroscope hardness corresponding to a certain composition, density, and method of preparation are shown in most cases for the metals and alloys. In addition, figures are given in many instances for the compressive and shearing strengths, moduli of rupture, and Erichsen values. The circular also includes definitions of the properties treated and references to sources.

Experiences with Thin Concrete Slabs*

By JOHN V. SCHAEFER,
President, Cement Gun Construction Co.

In 1916 the Cement-Gun Construction Co. was doing some work for the Ford Motor Co. at Detroit. One day the architect asked us to help him solve this problem.

One of their main buildings, known as Building A, is about 85 ft. wide and 900 ft. long. The building adjoins the power house, and in building it they planned to use the roof for a spray pond for cooling the cooling water of their big gas steam engine. To that end they built the roof in bays about 85 ft. square. Each bay was dished to the center about 18 in., with a uniform slope from all edges to the center, where there is a sump about 20 in. square, from which a cast iron pipe conducts the water back to the pumps.

The roof has a 6-in. concrete slab. Along one edge of the roof was a parapet wall. The other edge was flat. The surface was not all even; in some places where hangers had been required in the room below, holes had been cut through the roof for the hangers and the hose patched and the hangers mounded over. In addition, some of the bays had pent houses covering heads of elevators, and the brick piers for supporting the spray pipe had been placed right on the roof.

A few bays of this roof which had been put into service had been covered with a membrane roofing many plies thick. In some places the total thickness was as much as ⅝ in. This membrane was made continuous over the ridges between bays and flashed along parapet and around piers and pent houses.

The sprays were in use pouring hot water on these roofs from Monday morning until Saturday night—over Sunday they were shut down, so that through the week they were subjected to nearly boiling hot water, and over Sunday they might be subjected to a temperature of 20° below zero. Under these conditions the membrane had gone to pieces and the matter was a serious one, as the room below was used for such purposes as pattern shop, dynamo winding, moving picture laboratories, etc., and of course any leakage through this roof was a serious matter.

We were asked whether we could shoot a waterproof coating of gunite on these roofs and make them tight. Here was a problem. The underside of this roof slab was at a fairly constant temperature the year round. The top surface had a weekly temperature range from about 200° above zero to 20° below zero. We figured that any concrete coating applied to the top surface of these roof slabs would have to crack on account of contraction and expansion. Our suggestion was to place on the roof a thin gunite slab heavily reinforced, and so placed that it would not be attached to the concrete roof slab at all.

We were given an order to treat two of the sections in accordance with our theory. We first mopped the surface with pitch. We then placed a double layer of No. 7-A American Steel & Wire Co.'s triangular mesh, with main wires at right angles and with end and side laps securely tied. Over the ridges between bays we built curbs 8 in. high split through the center so as to make an expansion joint, and over the top of the curbs we placed a galvanized iron cover with the edges bent down about 2 in. to prevent the spray from falling into the open joint. This gave us a sort of a shallow pan or basin, 85 ft. square, 18 ft. lower at the center than around the edges, and with free ends all around the edges. Of course, along one side we flashed into the parapet wall.

These two were fairly successful. However, some small cracks did open and there was some slight leakage. We never found out exactly where the leakage came from. The cracks seemed to be surface cracks only and we never believed that they caused the leakage. However, the work was so satisfactory that the rest of this roof was done in the same manner and has been in continuous successful use for several years.

When a year later four additional bays were built we covered these in the same way, except this time we saw to it that the roofs were left smooth, without any obstructions, and the brick piers were built on top of our gunite basin, instead of projecting through them. Furthermore, this time we supplied more reinforcement and we were more particular about preventing a bond between the roof slab and the gunite. We first placed a ½-in. layer of dry sand all over the roof. On this, to prevent blowing it away with our cement guns, we placed a thin layer of tarred felt. Over this, with suitable spacers, we placed our double layer of wire mesh, and in addition a ¼-in. square rod 18-in. centers in both directions. Through this we shot a 2½-in. layer of gunite. These basins never even showed a hair crack, and we believe that we successfully accomplished what we set out to do, namely, to build shallow basins floating on a layer of sand, which were free to contract and expand independent of the roof, and which were so heavily reinforced that they would come and go with contraction and expansion without cracking. These roofs never leaked.

Now a word as to the theory on which we proceeded. The co-efficient of expansion of concrete and of steel is the same to within a very small fraction—so small that for work like the above the difference is negligible. If a slab like the above is free to move, there is no reason why expansion cracks should occur. The center was anchored by the sump; the edges were free to come and go, except for the friction, and as this friction on a large area would be very great, a sufficient amount of steel was needed to actually pull and push the slab as it contracted and expanded. In the case of a slab held fast at the ends or at intervals like the wall of a building, such a slab cannot come and go at will. When contraction occurs there is a shortening of the structure, and if the ends cannot move toward each other then this shortening must be taken care of by a crack, as concrete will not stretch, and somewhere about 300 lb. per square inch, it suddenly gives way. Such a slab simply cracks in one or more places at the weakest spots, the sum total of the width of the cracks being equal to the total amount of contraction.

Steel, on the contrary, stretches approximately in proportion to its stress up to a certain point called its elastic limit. Now, assuming roughly that concrete will stand 300 lb. and that at 10,000 lb. steel is stretched but a very little, if we give a slab steel reinforcement equal to 300 ÷ 10,000 = .003 as much cross section in steel as it has in concrete, we have a slab which when it contracts will not crack in one or two places. Every fractional inch of its length will stretch the exact amount of that fractional inch of steel. We will not have a few visible and dangerous cracks; we will have millions of microscopic cracks, none of them wide enough to ever let water through. It is upon this theory that we have proceeded, and our success thus far has been gratifying.

Equipment for Engineering Repairs to Timber Ore Docks.—On docks of any considerable size, some equipment is necessary to make emergency repairs. Although large general repairs are frequently let out to a contractor who furnishes his own crews and equipment, there are many accidents on a busy dock that can not wait the delay of securing a contractor to do the work. Depending upon the character and extent of the dock, this equipment may consist of cranes, derricks, pile drivers, etc., mounted on trucks or skids for land work and on scows for work around the water fronts of the dock. Floating drivers and derricks should be equipped with pumps, hose and jet for use in driving and pulling piles. A very good arrangement, according to a 1920 Committee Report of the American Railway Bridge and Building Association, is to use a long scow, with pile driving leads on one end and a stiff-leg derrick on the other end, both operating from a hoisting engine placed at the center of the scow on a reversible platform or circular track, so that the engine can be faced in either direction to operate either the pile driver or the derrick as the case may be. A swinging engine may be placed upon the derrick end of the scow to be used in swinging the derrick boom. Such a scow should be about 32 ft. by 100 ft. in size and 5 or 6 ft. in depth. This will handle pile-driving leads 60 ft. long and a 10-ton derrick with a 60-ft. boom. The great advantage of this outfit is that a small number of men will operate it and it is quickly adaptable to either pile driving or derrick work. If a 3-drum engine is used and a clamshell bucket is provided, small shoals can be dredged and at times save the use of an expensive dredging machine. The tools required with an outfit of this sort include axes, saws, chisels, augers, jacks, blocks and tackle, wrenches, etc.

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*From a paper presented at the annual [illegible] of the American Concrete Institute, Chicago, February, 1921.

Action of Sea Water on Concrete

A further report of an investigation made by the Aberthaw Construction Co., of Boston, to determine the effects, both mechanical and chemical, of the action of sea water and varying temperatures upon concrete piers of different composition, has been issued recently in pamphlet form by the Aberthaw Company.

In January, 1909, 24 concrete piers were manufactured in the U. S. Navy Yard at Charlestown, Mass. They were then hung under the cap log of a wharf at the Navy Yard. The length of each pier was such that the top was always above high water, while the bottom was always immersed in water. Thus in cold weather the piers were alternately subjected to freezing and thawing.

The cement used in the piers was of various brands. The sand was obtained from banks at South Acton, Mass. It was clean and sharp, weighing 97 lb. per cubic foot when dry. The rock was broken trap, passing through a 1¼-in. ring, the dust being screened out.

The specimens were poured in a horizontal position, a ⅝-in. square twisted steel bar being imbedded in each pier to give it stiffness for handling. The piers were about 16 ft. long and had an average cross section of about 1.8 sq. ft. The materials were carefully measured before being fed to the mixer. Each batch was dumped from the mixer two minutes after the first water was added to the materials. The concrete in the forms was thoroughly spaded and tamped.

The piers remained for five weeks in the building and then were hung from the cap log. They were examined from time to time, photographs being taken to show their condition.

In 1920 the piers were lifted off the log and were found covered with a ¼-in. thick coat of oil mixed with débris. This coat extended to within 5 or 6 ft. from the bottom, where the oil formed only a thin covering. The bottom of the piers were covered with sea growths; no barnacles, however, were found. It was assumed that they were destroyed by the crude oil floating on the water.

The make-up of the piers and the condition in which they were found at the various examinations are summarized in Table I.

TABLE I. MAKEUP OF TEST PIERS AND CONDITIONS AT VARIOUS EXAMINATIONS

Sample No.	Proportions.	Consistency.	Date of immersion.	Condition of piers Mar. 3, 1910.	 Dec. 17, 1913.	 June 9, 1920.	Remarks.
1	1-1-2, 248 lb. water	Dry	Feb. 27, 1909	Slight surface erosion	Badly eroded	Cracks; badly rotted	
2	1-1-2, 295 lb. water	Plastic	Mar. 1, 1909	Good	Slightly pitted	Slightly pitted	(1)
3	1-1-2, 425 lb. water	Very wet	Mar. 1, 1909	Good	Slightly pitted	Very slightly pitted	(2)
4	1-2½-4½, 165 lb. water	Very dry	Mar 1, 1909	Pitted*	Face badly eaten	Same as in 1913	(2)
5	1-2½-4½, 195 lb. water	Plastic	Feb. 27, 1909	Good	Slightly pitted	Badly pitted	
6	1-2½-4½, 345 lb. water	Very wet	Feb. 23, 1909	Surface soft	Slightly pitted	Badly pitted	
7	1-3-6, 182 lb. water	Dry	Feb. 27, 1909	Slightly pitted	Entirely eaten through	Entirely eaten	
8	1-3-6, 240 lb. water	Plastic	Feb. 23, 1909	Good	Slightly pitted	Back badly eaten	
9	1-3-6, 343 lb. water	Wet	Feb. 23, 1909	Good	Slightly pitted	Corners eaten	
10	1-1-2, 305 lb. water	Wet	Feb. 27, 1909	Good	Good	Slightly pitted	
11	1-3-6, 353 lb. water	Wet	Feb. 27, 1909	Good	Slightly pitted	Pitted; hole front face	
12	1-1-2, 325 lb. water	Wet	Feb. 27, 1909	Good	Slightly pitted	Slightly pitted	
13	1-3-6, 345 lb. water	Wet	Feb. 27, 1909	Good	Face, edges eaten	Badly eaten; rotten	
14	1-1-2, 330 lb. water	Wet	Feb 23, 1909	Good	Good	Face slightly pitted	(3)
15	1-3-6, 335 lb. water	Wet	Feb. 27, 1909	Face soft	Edges eaten	Conc. rotted ½" deep	
16	1-1-2, 315 lb. water	Wet	Feb. 23, 1909	Good	Good	Slightly pitted	(3)
17	1-3-6, 293 lb. water	Wet	Feb. 27, 1909	Good	Slightly eaten	Badly pitted	
18	1-1-2, 339 lb. water	Wet	Feb. 27, 1909	Good	Slightly pitted	Slightly pitted	
19	1-3-6, 370 lb. water	Wet	Feb. 23, 1909	Good	Badly eaten	Disappeared	
20	1-3-6, 275 lb. water	Wet	Feb. 23, 1909	Good	Slightly eaten	Badly pitted	
21	Lost in handling.						
22	1-3-6, 325 lb. water	Wet	Feb. 23, 1909	Little change	Badly eaten	Entirely gone, middle	
23	1-3-6, 298 lb. water	Wet	Feb. 23, 1909	Cracked	Badly eaten	Badly rotted	
24	1-3-6, 275 lb. water	Wet	[illegible]	Face soft	Slightly eaten	Badly pitted	

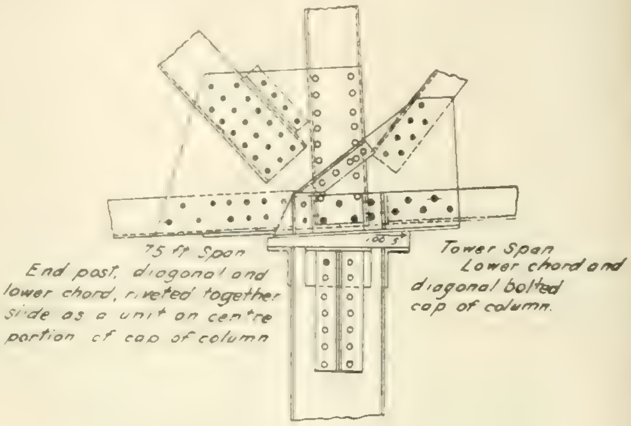
*Fine material eroded. [1]Specimen in very good condition. [2]Top half covered with oil. [3]Very good condition

Sled-Mounted Outfit for Driving Test Piles.—A drop hammer outfit mounted on sleds and operating on the frozen surface of the river was used in putting down test piles at the site of Bastican River bridge at Bastican, Que. A 2,200-lb. drop-hammer was mounted on four bobsleds with the boiler, hoisting cable and drums on a "stone-boat," thus enabling the whole outfit to move from one spot to another over the frozen surface of the river under its own power, by means of a cable made fast to a tie driven into the ice. Wooden piles, spliced one on top of the other, were driven at the approximate location of piers No. 1, 2, 4 and 5, to a depth of some 90 ft. below the level of the river bed in the channel, with an average penetration of 4 or 5 in. for the last blow under a drop of 25 ft. Borings were also made at piers No. 2 and 5 with a hand-operated auger worked inside a small pipe which was driven by means of a light hand-operated drop hammer.. While the tests were being carried out the water began to rise over the ice, forcing the contractor to haul his outfit hurriedly onto the bank and hindering any further operation.

Expansion Joints for Rouge River Bridge

The Rouge River Bridge, a 651-ft. deck truss steel structure, was described by A. B. Crealock in the Contract Record, November 17, 1920. The new structure is on the boundary line between Ontario and Quebec and replaces an obsolete bridge. The old bridge had steep winding approaches, being barely visible from them. To give an unobstructed view of the new bridge from both approaches, it was necessary to place the bridge on a 5 per cent grade.

The new bridge consists of three 75-ft. spans, one 112-ft. river span, two 80-ft. spans, two 32-ft. trestle spans and three 30-ft. trestle spans. The roadway is 24 ft. wide; there is one sidewalk 6 ft. wide cantilevered from the truss. The live load is 100 lb. per square foot, with a 20-ton truck on the roadway in addition. The two trusses were made alike for econony in fabrication, although the truss not carrying the sidewalk has less load.


75 ft Span
End post, diagonal and lower chord, riveted together slide as a unit on centre portion of cap of column
.005
Tower Span Lower chord and diagonal bolted cap of column.

Details of Expansion Joint Over Column.

One abutment and the tower pedestals rest on piles driven to rock. The other abutment rests on hardpan. The floor is concrete reinforced with expanded metal.

The expansion joints (see sketch) are arranged so that the end of one truss slides on the column, the end of the other is fixed; but both are centered on the column cap.

Employment Conditions Improve in February.—Reports on employment conditions for February, as compiled by the U. S. Bureau of Labor Statistics show that in ten out of fourteen groups of industries there were increases in the number of persons employed in February. In four there were decreases. In eight groups there were increases in money paid to employees; in the other six decreases. Increases in the number employed in February, 1921, as compared with January, 1921, included 42 per cent in the woolen industry, 21.1 per cent in men's ready-made clothing, 20.8 per cent in hosiery and underwear, 17 per cent in cotton manufacturing, 12.9 per cent in cotton finishing, 8.4 per cent in boots and shoes, 3.9 per cent in silk, 1.3 per cent in automobiles, 8 per cent in iron and steel, and .2 per cent in leather.

Wholesale Prices 1917-20 and Average Prices for 1913

The accompanying tabulation reprinted from the February monthly Labor Review shows the wholesale prices for minerals and metal products and building materials in July, 1917 to 1919, and by months for 1920, as compared with the average prices in 1918. The figures were computed by the U. S. Bureau of Labor Statistics:

WHOLESALE PRICES FOR MINERAL AND METAL PRODUCTS AND BUILDING MATERIALS IN JULY, 1917 TO 1919, AND 1920, BY MONTHS, AS COMPARED WITH AVERAGE PRICES IN 1913.

Article and Unit.		July			1920											
Mineral and Metal Products—	1913.	1917.	1918.	1919.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Coal, anthracite, chestnut, 2,240 lb.	$5.313	$5.933	[illegible]	[illegible]	$8.518	$8.513	$8.514	$8.522	$9.059	$9.462	$9.551	$9.711	$10.541	$10.536	$10.543	$10.548
Coal, bitum., run of mine, 2,000 lb.	2.200	5.000	4.100	4.000	4.100	4.100	[illegible]	5.500	6.000	6.000	6.000	6.000	7.100	7.100	7.100	7.100
Coke, furnace, prompt shipment, 2,000 lb.	2.538	15.000	6.000	4.172	6.000	6.000	6.000	10.500	12.000	15.400	17.250	17.600	16.625	15.125	8.100	5.875
Copper, electrolytic, lb.	.157	.318	.255	.215	.193	.191	.186	.192	.191	.190	.190	.190	.187	.168	.146	.137
Copper wire, bare, No. 8, lb.	.167	.338	.285	.244	.228	.230	.230	.230	.230	.230	.230	.230	.229	.206	.183	.170
Pig iron, Bessemer, 2,240 lb.	17.133	57.450	36.600	29.350	40.400	[illegible]	43.400	43.650	44.025	44.800	47.150	49.112	50.460	49.210	41.260	36.960
Steel billets, 2,240 lb.	25.789	100.000	47.500	38.500	48.000	55.250	60.000	60.000	60.000	60.000	62.500	61.000	58.750	55.000	49.700	43.500
Tin plate, domestic, coke, 100 lb.	3.558	12.000	7.750	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.500	9.000	9.000	8.625	7.500	7.000
Pig tin, lb.	.449	.620	.932	.702	.637	.603	.621	.623	.556	.490	.491	.472	.444	.406	.368	.339
Pig lead, lb.	.044	.114	.080	.056	.087	.088	.092	.090	.086	.085	.086	.090	.082	.073	.063	.048
Spelter, lb.	.058	.093	.087	.079	.097	.092	.089	.086	.081	080	.082	.083	.078	.075	.068	.060
Petroleum, crude, Pennsylvania, bbl.	2.450	3.100	4.000	4.000	5.063	5.513	6.100	6.100	6.100	6.100	6.100	6.100	6.100	6.100	6.100	6.100
Petroleum, crude, Kans.-Okla., bbl.	.934	1.700	2.250	2.250	2.900	3.000	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500
Petroleum, ref., water white, gal.	.123	.120	.171	.205	.224	.240	.250	[illegible]	.260	.260	.260	.260	.275	.290	.290	.290
Gasoline, motor, gal.	.168	.240	.241	.245	.257	.265	.280	[illegible]	.294	.300	.300	.300	.310	.310	.310	.310
Building Materials—																
Brick, red, domestic, building, 1 000	6.563	8.875	12.750	15.000	24.000	25.000	25.000	25.000	25.000	25.000	25.000	22.484	15.767	16.500	16.500	17.000
Cement, Portland, domestic, bbl.	1.580	2.120	2.600	3.250	3.370	3.400	3.400	3.560	4.325	4.575	4.800	5.100	5.063	4.980	5.100	4.920
Lime, common, lump, bbl.	1.078	1.900	2.500	2.700	3.525	3.800	3.875	4.100	4.100	4.225	4.600	4.600	4.600	4.800	4.800	4.800
Glass, plate, polished, 5 to 10 sq. ft., sq. ft.	.318	.400	.460	.580	.750	.780	.800	.820	.820	.820	.820	.820	.820	.820	.820	.820
Glass, window, single, B, 50 sq. ft.	2.221	3.420	5.700	5.700	6.555	6.555	6.555	6.555	6.555	6.555	6.555	6.555	6.555	6.555	6.555	6.555
Lath, 1½-in. slab, 1,000	4.284	5.625	5.125	5.750	17.000	17.000	17.000	17.000	17.000	16.000	16.000	16.000	10.500	10.500	9.125	9.125
Douglas fir, No. 1, 1,000 ft.	9.208	18.500	19.500	28.500	37.500	37.500	37.500	37.500	37.500	29.500	29.500	29.500	25.500	24.500	16.500	16.500
Hemlock, 1,000 ft.	24.227	28.000	34.500	41.000	53.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000	57.000
Oak, white, plain, 1,000 ft.	60.591	69.000	75.500	97.500	186.000	186.000	230.000	230.000	230.000	228.500	228.500	217.000	185.000	185.000	175.000	175.000
Pine, yellow, flooring, 1,000 ft.	44.591	57.000	60.000	73.000	112.000	139.000	139.000	160.000	160.000	160.000	160.000	157.000	157.000	152.000	124.500	124.500
Shingles, red cedar, 1,000	1.967	3.000	2.080	[illegible]	6.570	6.820	6.080	5.720	4.930	4.190	4.570	4.960	3.880	3.220	3.090	2.590
Nails, wire, 8-penny, 100 lbs.	1.819	4.100	3.600	3.350	4.600	4.600	4.100	4.100	4.100	4.100	4.100	4.350	4.350	4.350	4.150	3.350
Pipe, cast-iron, 6-in., 2,000 lb.	23.371	65.525	61.750	50.920	67.300	70.300	71.500	74.300	76.300	76.300	76.300	76.484	77.220	77.220	77.220	66.780
Steel, structural, lb.	.016	.062	.033	.027	.027	.029	.033	.035	.035	.085	.032	.031	.032	.032	.031	.028
Lead, carbonate of (white), lb.	.068	.128	.136	.130	.146	.151	.155	.155	.155	.155	.155	.155	.155	.155	.149	.141
Linseed oil, raw, gal.	.462	1.120	1.770	2.115	1.770	1.770	1.803	1.828	1.690	1.653	1.520	1.413	1.215	1.076	.893	820
Turpentine, spirits of, gal.	.428	.420	.700	[illegible]	1.885	[illegible]	[illegible]	[illegible]	2.475	1.868	1.599	1.624	1.473	1.230	1.098	.790

Licensing Professional Engineers.—Two of the license bills now being advocated by the American Association of Engineers before various legislatures have succeeded. In Indiana the bill has become a law; in North Carolina, the bill has passed the Senate and the House and is waiting the Governor's action. There are 21 other states considering similar bills. The Indiana bill has some of the features of the A. A. E. Model Law and some of the features of the Engineering Council's Bill. The Indiana law does not define engineering and omits the mentioning of society membership as a qualification for licensees. The North Carolina bill is compulsory and provides licensing for engineers, land surveyors, and architects; and also provides for reciprocity.

Settlement of Disputes in Building Trades.—The new general agreement completed a few days ago between the St. Louis (Mo.) Building Trades Employers and the Building Trades Council contains the following clause:

> Article 5. There shall be no stoppage of work because of jurisdictional disputes. The awards made by the National Board of Jurisdictional Awards shall be enforced by the Building Trades Council of St. Louis. Cases not covered by awards of the National Board are to be adjusted by the St. Louis Building Trades Council.

A similar clause is incorporated in the new Chicago wage agreement referring all jurisdictional disputes not covered by national awards to the local Joint Conference Board with appeal to the National Board if desired.

Changes in Retail Prices of Food in the United States

The retail food index carried by the Bureau of Labor Statistics of the United States Department of Labor shows that there was a decline of 9 per cent in the retail cost of food to the average family in February as compared with January.

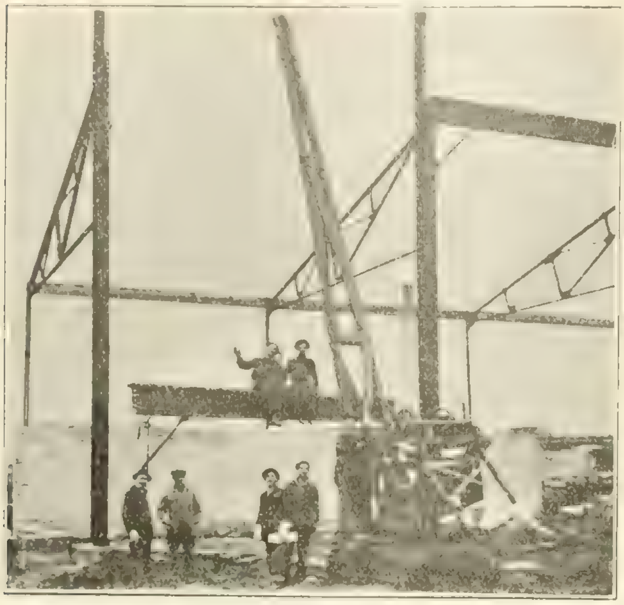
Prices of 43 food articles are reported to the Bureau of Labor Statistics each month by retail dealers in 51 important cities. From these prices average prices are made for each article. These average prices are then "weighted" according to the quantity of each article consumed in the average workingman's family. From January, 1913, to December, 1920, 22 articles of food were used in this index, but from January, 1921, 43 articles are included in the index number. The index number for 1913 is taken at 100. The index number for February, 1921, was 158 or 58 per cent above the 1913 level.

Year and month.	All articles combined.
1920—	
Av. for year	203
January	201
February	200
March	200
April	211
May	215
June	219
July	219
August	207
September	203
October	198
November	193
December	178
1921—	
Av. for year	
January	172
February	158

Reinforced Concrete Skyscrapers.—The pioneer reinforceed concrete skyscraper was the 16-story Ingalls Bldg., built in Cincinnati in 1903. Since then, according to Concrete in Architecture and Engineering, some 300 reinforced concrete buildings over 10 stories high have been completed or under way. In Minneapolis and St. Paul alone there are 26 buildings from 10 to 14 stories high with reinforced concrete structural frames

Adaptation of Self-Feeding Bucket Loader to Steel Erection

Six men with the aid of the machine shown in picture, completed a nine-day job with two lean-to trusses and one apex truss in less than a week's working time at the plant of the Barber-Greene Co., Aurora, Ill. The Barber-Greene Co. previous to the arrival of the structural iron workers rigged up one of its self-feeding bucket loaders in the fashion shown as a stiff-leg crane. The bucket elevator was removed and a power winch installed on top of the frame which houses the gasoline engine. At one side of the frame an A-frame was firmly attached with a platform at the opposite side weighted with sacks of sand to form a counter balance. This measured 32 ft. from the ground. A pole was lashed to the A-frame to give the boom a height of 50 ft. in order to put up the apex trusses. The original drive by crawlers did not need to be altered, and by means of the accurate control possible with the crawlers, no difficulty in maneuvering was experienced even though it was not possible to raise and lower the boom. Power was furnished as with the bucket loader proper by a Buda 25-HP. gasoline engine.



Steel Erection With Self-Feeding Bucket Loader Rigged Up with Power Winch and A-Frame.

Tax Exemption Causes Building Increase.—The first pronounced increase in home building at New York since the war was shown March 20 in a compilation of building statistics for the last two weeks. Plans for new buildings filed during this period were 61 per cent greater than those filed during the corresponding period last year. This impetus was attributed by Henry H. Curran, president of the Borough of Manhattan, to the tax exemption ordinance recently approved by the board of aldermen. This measure provides for a maximum tax exemption for ten years of $5,000 annually on all dwellings the construction of which is begun before April, 1922. The first two weeks the ordinance has been in effect have produced plans of homes for 1,076 families, as compared with 666 in 1920.

New Commission-Manager Cities.—Audubon, N. J., on March 15 voted in favor of the commission form of government; the vote was 668 for and 198 against. Lake City, Fla., on March 9 by a vote of 350 in favor and 65 opposed, adopted the commission-manager form.

Arizona License Bill Passes.—The bill licensing engineers and surveyors in Arizona has passed both the Senate and the House in the Arizona Legislature. This bill was introduced in the Arizona Legislature through the efforts of the American Association of Engineers.

Building Permits Increase 32 Per Cent in February.—The February building returns of Bradstreet's announced March 11 show a total expenditure in 146 cities for the second month of the year of $77,840,102. While this is a decrease of 25 per cent from February, 1920, it is a gain of 32 per cent over January of this year.

Personals

M. L. Kintz has been appointed city building commissioner of Canton, O.

Joseph Wells, C. E. Peterson and C. A. Norton have taken out incorporation papers for the Valley Contracting Co., Yakima, Wash.

B. B. Byers, of Pittsburgh, Pa., has been appointed manager of the Pittsburgh district for the Foundation Co., succeeding the late H. B. Kelsey.

Edmund T. Perkins, consulting engineer, First National Bank Bldg., Chicago, Ill., sailed on March 15th for Barranquilla, Colombia, South America. Mr. Perkins goes to South America to report upon construction work in which American capital is interested.

R. C. Semple, structural engineer, formerly with the Hofius Steel & Equipment Co., has opened offices at Rooms 416-17 Mutual Life Bldg., Seattle, Wash., and will engage in the designing, detailing, estimating and superintending of concrete and steel buildings.

Donald G. Coombs, for the past three years with the Braden Copper Co., Caletones, Chile, as assistant division engineer and office engineer, on the construction of a 10,000 ton smelter, has recently returned to Seattle, Wash., where he will be permanently located in the construction field. Previous to his Chile engagement he was assistant superintendent of construction for the U. S. Reclamation Service on the Meadow Creek and Rimrock Dams.

James Rowland Bibbins, of the Arnold Co., Chicago, has been appointed manager of the newly created Department of Transportation and Communication of the Chamber of Commerce of the United States. Mr. Bibbins brings to the new department a wide experience derived in consulting work dealing with transportation problems of some twenty cities in the United States and Canada. He has had to do with rapid transit problems, railroad and port terminal activities, and civic development. He has studied terminal problems in New York, Chicago, Baltimore and New Orleans, transit plans of Chicago, San Francisco, Pittsburgh and other cities and valuation of property in New York, Brooklyn and Chicago. The new Department of Transportation and Communication will have a wide range of activities. It will cover shipping, ocean and inland; steam and electric railroad transportation, air transportation, cables and telegraphs, postal facilities and highways.

Obituaries

Albert H. Wolf, a retired consulting and contracting engineer, of Chicago, died March 13. Mr. Wolf was born Aug. 16, 1855, at Woodville, Miss., and with his parents came to Chicago in 1863. After passing through the old Scammon School and the Chicago (Central) High School he studied civil engineering and later was first assistant civil engineer of the Chicago, Rock Island & Pacific Ry., which he left in 1875 to enter the lighthouse bureau, where he designed and had charge of several important lighthouses on the Atlantic. In 1877 he resigned from the government service and spent the next four years abroad, in continuing his professional studies at the Universities of Berlin and Strasbourg. On his return to the United States he practiced as consulting engineer first in Montana and later in Philadelphia, where he was associated with J. H. Linville, one of the most eminent engineers of his time. In 1884 Mr. Wolf returned to Chicago and opened his office as consulting and contracting engineer. Mr. Wolf at once took an outstanding part in the design and development and construction of skeleton constructed skyscrapers. He is stated to have used for the first time in any building in the old Chicago Telephone Building a fabricated column made up of wrought iron plates instead of the round cast iron columns. He also is said to have originated the system of windbracing now generally applied. Mr. Wolf retired from active practice in 1914.

Industrial Notes

The Wood Pipe Export Co. has opened an office at 775 Monadnock Bldg., San Francisco, Calif.

The Clyde Iron Works Sales Co. of Duluth, Minn., has placed its Pittsburgh agency with the John H. Carlin Machine Co. of that city.

The John H. Carlin Machine Co. of Pittsburgh, Pa., has taken the agency for the Wonder line of concrete mixers, hoists, pumps, back fillers, etc., in the Pittsburgh territory.

H. S. Greene has been elected vice president in charge of sales for the Barber-Greene Co., Aurora, Ill. Mr. Greene comes from the National Carbon Co. of Cleveland, O., where for several years past he was assistant sales manager. He is a brother of W. B. Greene, vice president and treasurer of Barber-Greene Co., and has been a director of the company for some time.

The Blaw-Knox Co., of Blawnox (Pittsburgh), Pa., on April 1st opened up a new sales territory in the Southwest, with headquarters in Kansas City, Mo. The company also recently established a district sales office in Birmingham, Ala. In addition, the Blaw-Knox Co. has sales offices in New York, Chicago, Detroit, Boston, Baltimore, San Francisco and Sheffield, Eng. The Kansas City office, which is located in the Interstate Bldg., is in charge of R. B. Randall, formerly connected with the company's Chicago office, who will be known as manager of the southwestern territory.

The Engineering Advertisers' Association, Chicago, held its annual meeting at the Great Northern Hotel, on March 8th and elected the following officers for the ensuing year: President, Keith J. Evans, advertising manager Jos. T. Ryerson & Son; vice president, Julius Holl, advertising manager Link-Belt Co.; secretary, D. T. Eastman, advertising manager Eagle-Picher Lead Co.; treasurer, J. B. Patterson, district manager P. H. & F. M. Roots Co. W. F. Leggett, advertising manager, Webster Mfg. Co., Benjamin Brooks, of the Clay Products Association, Guy S. Hamilton, advertising manager Conveyors Corporation of America, and Edward I. Pratt, advertising manager Kellogg Switchboard & Supply Co., were elected active directors and Mr. E. R. Shaw, president of Power Plant Engineering, was elected associate director. The Engineering Advertisers' Association now enters its third year of activity with many interesting and important subjects to discuss and with real co-operation among its hundred members.

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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The Restriction of Output by British Labor Unions

British engineering periodicals are giving much space to to discussions of trade union restriction of output. It is realized by engineers and business leaders that Great Britain will not be able to compete with America for the world's markets unless British trade unions change their present policy of opposition to labor saving devices, "payment by results," etc.

The Times Engineering Supplement (London) recently sent a questionnaire to representative manufacturers as to the effect of output restrictions by labor unions. To quote:

> As mentioned in the Engineering Supplement for November, Lord Weir has stated that during the last 12 months the output in his firm's works had been 40 per cent less than it would have been had all workers been free to undertake any work that was available and to produce all they could. This statement has been submitted to our correspondents, and they have been asked to say whether in their own works they had observed restrictions on freedom of employment and on production such as Lord Weir referred to, and if they had, what in their opinion would be the effect on their output, and on the number of workers employed in their works, if the restrictions were removed.
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> Before giving individual instances it may be useful to state the general effect of the correspondence. About 70 per cent of all who reply to the question say that in principle their experience has been the same as Lord Weir's. Some do not hazard an opinion as to the extent to which the altered conditions would enable their output to be increased. One or two put the increase as low as 10 or 15 per cent. and some as high as 50 per cent. On the whole Lord Weir's figure appears to be somewhat higher than the average estimate of our correspondents for their own works. From internal evidence, however, it seems questionable whether in a good many instances the writers have taken account of the effect on their own particular industries of a decrease in the output of ancillary trades. Having regard, moreover, to numerous instances that are quoted of increases of output amounting even to hundreds per cent which have resulted from the introduction of payment by results and admission of workers not committed to a standard of slowness, the estimates both of our correspondents and of Lord Weir appear to be well within the facts.

Few Americans, we believe, know the extent to which British labor unions have gone in restricting output. To quote:

> A few examples may be given of the way in which the opposition to intensive production is exercised.
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> A Midland firm of crane-makers found the output per worker decreased by about one-third, and at the pre-war pace men would be doing 50 per cent more than they are at present. In this works a man who was finishing a job on one machine involving a long final cut used his time to make ready another machine on which he was going to start and was promptly fined for operating two machines.
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> A Midland firm of motor-car makers with much the same restriction of output find that even automatic machine-tools are not allowed to produce their full output, and any man who makes himself singular by producing more than is directed by the shop steward or the trade union local committee may be fined or expelled, in addition to being subjected to such unofficial discouragement as having his tools hidden or stolen.
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> In a firm manufacturing special oil-burning apparatus no restriction of employment or production is found except among the tool-makers, and where previously unskilled men were trained to do this work the existing tool-makers refuse to admit them into the union.
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> From the South Coast shipyard it is reported that a rivetter was recently fined for turning out as much as he could when he was working piece-work.
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> In the experience of a road-locomotive works the trade union leaders declined to sanction an output bonus offered by the firm, which was accordingly dropped. The men affected were apparently unaware of the trade union action, and after some waiting inquired as to the progress of the scheme. When they learned what had occurred they overruled all the trade unions except the Joiners', which succeeded in persuading the men to refuse the output bonus, though at a cost to them of 36s. per week.
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> In the experience of some works trade unions deny that restrictions exist but enforce them secretly or indirectly. In others they arise from agreements made openly with the trade unions or from provisions enforced by law.

As to the reasons why British labor unions pursue such an economically ruinous policy there is a diversity of opinion, as indicated by the following quotations:

> About two-thirds attribute them (output restrictions) to the influence of trade unionist groups exerted without the co-operation of the bulk of the men. Of these over 10 per cent say that the restrictions are enforced in the teeth of the opposition of the rank and file by extremists who have control of the union mechanism. About twice as many also attribute the action of the unions to the influence of extremists, but say that it becomes operative owing to the apathy of the bulk of the trade union members, who could prevent the trade union action if they took the trouble to attend and vote at the meetings and would stand up against the influence and coercion of the minority instead of yielding to a desire for a quiet life. Another 10 per cent say that in their belief the restrictions are due to the influence of groups in the trade unions supported by the wishes of the bulk of the members. Various writers attribute some part of the restrictions to causes such as propaganda, legislative support, and the desire to protect the less capable workers. Throughout the answers great stress is laid on the ever-present fear of unemployment and the belief that the risk of unemployment is reduced by restricting production.

Note particularly the last sentence just quoted. In our opinion it states the great underlying reason why labor unions restrict output. If so, a remedy for this objection should be found and it seems to devolve upon governments to find it, or at least to see that the remedy is applied when discovered. To quote again:

> A number of writers relate cases in which the whole of their men wished to have payment by results, and in this wish were supported by the trade union officials, members, and men on the works committee, but were overruled by the union decision.
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> A large Tyneside firm of engineers and shipbuilders express the opinion that the root of the matter lies in the systematic propagation of false economic doctrines at certain Labor Colleges and Centers. This view appears from various parts of the country and in many industries. Such teachings in the opinion of one writer, often come from some forceful leaders of thought "who think deeper than many of their fellows, but not deep enough." Another circumstance on which stress is laid in a variety of answers is that trade union restrictions are largely possible through the artificial legislative and executive protection that trade unions have received from the Government. This view is most fully expressed by a Scottish firm, for example, employing some 1,200 hands on the manufacture of chemical plant and water mains. At present they say trade unions are backed up and protected by the various Government Departments, and their movement is safeguarded by a variety of laws, some of which may have been necessary and useful when they were passed, though others were "obviously passed for the purpose of purchasing the workmen's votes." Having now served their purpose they ought to be abolished. This sort of protest against the legislative privileges in favor of trade unions and against the freedom of individual workers occurs in replies from many branches of trade in all parts of the country. One or two add that the disposition to restrict output was notably increased by the "Government's use of time and lime contracts," which taught both works and workers how to make more profit from slow and costly production than from rapid and cheap.

Whenever the leadership of any organization is determined by election the methods of the professional politician are likely to be found. Thus labor union leaders resort to the same practices as are common among politicians. Moreover, labor union leaders are usually of the same type as politicians—extreme in opinion, dogmatic, pugnacious, loquacious. To quote in illustration:

> A view, however, which is commonly and variously expressed may be illustrated in the answer sent from a Tyneside shipyard. It attributes restrictions to groups of trade unions, and not to the spontaneous wish of the bulk of the employes; but it states as a well-known fact that the better-class workman never attends trade union lodge meetings, knowing that if at such meetings he advocates moderate opinions, he will be threatened with violence by extremists. As a result trade union lodges are run by the younger and more irresponsible members. Much the same view comes from a south coast shipyard, where, in the writer's opinion, "the young hot-headed men rule the roost, and the steady level-headed workman does not attend meetings." The writer goes on, however, to point out that a decision in favor of doing less work or claiming more privilege is always likely to be more popular than one which requires increased energy or some apparent

The restriction of labor union membership is frequently mentioned by British employers as being a bar to prosperity. The editor of the Times Engineering Supplement says:

> There is evidence that in many of these trades the men would be willing to agree to cancel these monopolies if in return other trades were thrown open to them, but their trade unions and those who inspire and manipulate them will not allow this. Among these trades is the trade of laying brick, which for ordinary domestic purposes and similar straightforward work is a simple trade, of which any man could be taught enough in a few weeks to earn his money better than most bricklayers are earning it at the present time. Because of the monopoly that is claimed by bricklayers, tens or hundreds of thousands of families are homeless, or housed in uncomfortable, unhealthy and extravagant conditions, and many works are unable to accept orders and are compelled to restrict the extent of their employment, because they have not the space in which to carry the orders out. What new houses have been built have cost several times as much as they would have cost years ago, and much of this excessive cost comes out of the rates and taxes, which are a burden on workmen as on every one else.

It seems to us, however, that in restricting the number of members of a labor union there is at bottom an economic justification. Excessive competition, whether among workmen for employment or among employers for business, is admittedly an economic waste. How to limit such competition without destroying initiative and efficiency is a problem, but that competition should be limited is beyond question. There is overproduction and violent fluctuations in prices and in annual incomes as a result of excessive competition. Why, then, should labor unions be blamed for attempting to limit the number of members in each trade? We see no reason for decrying in them a policy that is not in itself an economically wasteful policy.

The grand labor problem that confronts not only Europe but America is how to bring workmen to see that they serve their own interests best when they best serve the interests of society as a whole. Society as a whole gains when per capita productivity increases, but a sudden great increase in productivity in a given trade may be temporarily disastrous to men in that trade. A new invention may benefit both its inventor and society as a whole, but it may throw thousands of men temporarily out of a job. To overcome the resistance of such men to the introduction of labor-saving devices, whether machines or methods of payment, some plan must be devised whereby the men displaced are not deprived of any income even temporarily. This, it seems to us, is not a difficult problem to solve. None the less its solution has never been seriously attempted.

The Socialistic Labor Party in Great Britain

Editorial in London Engineering.

The Labor Party may fairly be said to stand for socialism, and it is curious what a complete lack there appears to be of any constructive method in their ranks. Socialism in the broad sense has made much headway in this country in the last generation, but in practically all cases its manifestations have been quite unable to stand on their own feet and have had to be supported by the taxpayer, or the ratepayer. If labor is to make its case that this, that and the other industry should be run by the state or the municipality, it would surely appear a logical and politic procedure to attempt to make a financial success of such socialistic organizations as we already have in existence. The plain fact is that practically all the socialistic methods which we have at present in operation are parasitic on the private initiative which the socialist would tell us is undesirable, and should be done away with. Experience has so far shown that when the state takes over an industry, that industry ceases to be revenue-producing and becomes revenue-consuming. There are many examples of this, and apparently at least one speaker for labor would add the coal industry to the list of revenue-consumers and incidentally, of course, eliminate the revenue which it has hitherto paid in taxes.

The socialist case well put make a not unattractive picture of a community of the future, but the plain man may be forgiven for wondering where the revenue is coming from to run the mulitifarious state and municipal activities which it postulates. Past experience can only suggest that when the state has taken over everything then everything will require subsidy from the public revenue, and yet that revenue will have no source.

Economic Science as a Means for Preventing Cycles of Trade Depression

From an editorial in The Engineer, London, Jan. 7, 1921.

There is probably no subject over which the historian of the future will exercise more ingenuity than the depression in trade which began in the middle of the departed year. A dozen good reasons can be given why trade should flourish, and every one of them must be disposed of before the present "slump" can be explained. We shall not attempt that exacting task; we shall not venture to evaluate the explanations that have been put forward; we shall not venture to add one more to the ever-lengthening list of assumed causes. Let future economists crack that polyhedral nut. Suffice it for us to say that a more striking example of the black ignorance which exists in the world of the true science of economics cannot be found than this simple fact, that we could not foresee the coming of this depression 12 months ago; that we cannot explain it now; that we are as unable to dissipate what ought by all reason to be no more than a phantom as we should have been, had we foreseen it, powerless to prevent its approach. In a future generation all that will be changed. Men will recognize the inexorable laws of economics and bow to them as they bow now to physical laws. They will know, they will analyze, they will measure, they will direct economic forces, and they will laugh at our absurd world of 1920, that was actually out of work at the very time when it stood greatly in need of all natural and manufactured commodities.

We have said that we would not offer any opinion on the causes which have led to the condition of affairs in which the new year opens, but we may be allowed to make one general observation. Cycles of trade are in part the outcome of events over which man has as yet very little control—a wet season, for example, may destroy the harvest or a dry one may ruin the wool-clip—and in part the result of events of a human kind, events, that is, which man may in some measure modify and direct. The state of trade in Russia followed naturally upon the revolution and the state of trade in Ireland upon the rebellion. These, fortunately, are abnormal occurrences, and can no more be taken into general account than earthquakes in Europe. There remains a group of constant phenomena directly under the rule of man, and it is them that the economist has to balance in his calculations. That there is a definite and precise science of these things we persist in believing as firmly as we believe that the world's knowledge of that science is but little removed from crass ignorance. A curious but striking corroboration of the existence of this ignorance may be found in the fact that everyone, from the member of a village debating club to the member of a House of Parliament, believes he is competent to discuss and to dictate economic policy. In the dark ages of natural science there was a similar general assumption of knowledge. The husbandman told by the moon when to sow seeds, the housewife treated illness by empirical methods, natural philosophy was discussed by churchmen and the course of thought was directed and controlled from the pulpit and confessional. Gradually, as step by step men here and there groped their way through the mists of ignorance and prejudice to truth and independence, scientists became segregated into a separate caste to which others deferred, and from which others sought that knowledge which, at length, they had been forced to admit was not the common property of all. Economic science must and will follow the same course. When it is established on a firm basis, when we shall no more think of entrusting the direction of the currents of trade to inexperts in the science of economics than we should think of now allowing a mixed party of members of Parliament to dictate the engineering steps to be taken for the training of a river or for the erection of a super-power station, then, and not till then, shall we find means of preventing cycles of trade depression; then, and not till then, shall we obviate the dislocation of industry by the quacks in economic science who control, too frequently, the course of labor and will command, if they can, the course of capital. We must seek by all means to convince the laymen of the world that economics is a science as profound as any natural science, and that it must be left to those who have made a study of it. The ill that is now done by quack remedies for economic ills is incalculable. By constant propaganda in the press, on the platform, by books, and by word of mouth, the truth must be driven home, and just as by popular exposition of natural science respect for its difficulties is won, so by constantly placing before all people the true elements of economic science we may hope to check the indiscriminate and uncontrolled expansion of false and dangerous doctrines.

Should Road Foundations Be Rigid or Elastic?

Editorial in Municipal Engineering and The Sanitary Record, London, Oct. 14, 1920.

In the most recent of the pleasant monthly causeries under the title of "Roads and Roadmakers" which that esteemed County Surveyor, Mr. Alfred Dryland, regularly contributes to a motoring periodical, we observe that he discusses—apparently after closely following the correspondence on the subject which appeared in Municipal Engineering—the expediency of tearing up at great expense concrete foundations 6 in. to 9 in. thick in London thoroughfares and substituting new concrete 9 in. to 12 in. thick. "Some critics," he writes, "deem such work an absolute necessity of the time; but there are others," he goes on to say, "who express the opinion that this process is very largely a waste of time and money; that if settlements were made good and poor floating replaced the old matured concrete is better suited to withstand the stress of traffic than similar new material, it may be of greater thickness, but subjected at an early stage in its life to jars and stresses likely to prevent such perfect setting and homogeneous consistency as has been attained under more favorable conditions by the old concrete." Our readers will remember that both these aspects of the subject have been fully and frequently discussed in Municipal Engineering, the balance of opinion being adverse to the destruction of the old concrete foundations, an opinion which is evidently shared by this experienced and capable county surveyor.

But it is apparent that Mr. Dryland is not convinced that rigid concrete foundations to wood and asphalt macadam surfacing are really obligatory, for "others hold the opinion," he says, "that they are a mistake, as the concrete submits the covering surface to a condition comparable to the interposition of the horseshoe 'between the hammer and the anvil,' and the surfacing being generally more pliable than the hammer or the anvil, is bound to be distorted by the blows rained upon it by modern heavy units of traffic. This class of critic argues," he states, "for instance, that corrugation of road or rail is an effect of rigidity, and that the way to resist abrasion and corrugation is to give to your road bed such elasticity that the stresses from the shocks on the surfaces are dissipated and taken up therein." Mr. Dryland goes on to say that he recently inspected trials in a metropolitan suburb where asphalt macadam has been laid on a thick bed of clinker and is standing up to motor omnibus and other heavy traffic as well as the adjacent wood paving which was laid at the same time on 9 in. of reinforced concrete, and in another case is giving more favorable results than similar surfacing founded on strengthened macadam road crust of equal thickness. . . .

Mr. Dryland refers to the destruction of granite blocks by steel-tired wagons, which is probably, he thinks, the result of inelastic construction attacked by an inelastic wheel. And he concludes with the very pertinent query: "Is elasticity desirable in a road bed? If so, to what extent, and how can it best be obtained?" These are questions to which road engineers might well turn their attention. We are convinced that the majority of engineers will agree that a solution of the problem should be found as to whether existing concrete foundations should be destroyed and replaced by new concrete whose superiority to the old is doubted, and whether elastic or rigid foundations are best suited to wood, granite, or asphalt paving. Inasmuch as the Institution of Municipal and County Engineers does not undertake research work, as is the case with most other engineering bodies, we think that the Roads Department of the Ministry of Transport could with great economic advantage to the community undertake such an investigation. It is urgently needed, for the existing knowledge on the subject is much too nebular in character.

The Engineer and the Public

Editorial in Engineering, London, Nov. 19, 1920.

Though modern civilization rests mainly on the work of the engineer who furnishes transportation for personnel and material, provides us with water and light, and gets rid of our wastes, it cannot be said that he has hitherto played any prominent part in the conduct of public affairs. France, it is true, elected an engineer to the Presidency in the person of Carnot, but this example constitutes merely the exception that proves the rule. We have never had in England an engineer in the position of Prime Minister, nor, indeed, in any ministerial office until the tangle into which certain departments of Government had muddled themselves during the war made it imperative to call for the services of men of "push and go." As a consequence during the later years of this period of stress the engineer occupied a more prominent position in the public estimation than he had ever done before. It cannot be said that his advent was enthusiastically welcomed by the established authorities in either the civil or the military departments of state. The reluctance of the War Office to recognize that the trench welfare deadlock, predicted years ago by Mr. Bloch, could only be overcome by the aid of the engineer, is notorious, but it is also true that even though admitted perforce into the Ministry of Munitions the engineer was, so far as practicable, precluded from dealing with any but purely technical matters. He was, for example, excluded from the negotiations which took place on various occasions between the Ministry and the trades unions, and this exclusion of experts from the national side of these conferences was responsible for not a few of the labor troubles which afflicted the state during the latter half of the war. Like the country magistrate in the well known anecdote, the political heads of the departments found that to listen to both sides of a case had a confusing effect on their minds, and that it was simpler to accept the statements of the union representatives as impartial and complete presentations of the matters at issue.

Simplicity is at times apt to prove expensive and undoubtedly did so here, and if the co-operation of the engineer continues in the future to be as distasteful to our public authorities as has commonly been the case in the past, the liquidation of our enormous war debt will prove far more onerous than it need be. As matters stand the public attaches far more weight to the utterances of the non-technical politician on technical matters than it does to those of the engineer. When the L.C.C. gave evidence before the committee on London traffic its principal witnesses were not the able engineers in its employ, but the late Sir L. Gomme and the leader of a political party, both of whom gave completely erroneous evidence on highly technical points. The former, indeed, proposed to recast Newton's laws of motion, maintaining seriously that the heavier a body in motion might be the easier it was to stop it, while his colleague in an attempt to disprove that the tramcar caused more obstruction than the motor bus gave vent to views which, carried to their logical conclusion, implied that urban traffic would be best handled by long trains of coupled tramcars. Of course, no engineer could have been found to back either of these suggestions, but the marvel remains that such evidence was accepted as of a technical character by the Commission.

During the war much more weight came to be attached to the views of experts, but the innovation was by no means welcomed and the complaint was made that the committee which reported on electrical power distribution in this country did not include among its members aldermen and councillors. In America matters have been still worse, and Mr. Waddell, the eminent bridge engineer, records a case in which the position of county engineer was filled by a lawyer since it was held that the post must be filled by a politician whose peculiar qualifications are not fostered by the engineer's calling. Nevertheless, there has of late years been a strong movement in America to take certain public activities "out of politics." One method of doing this has been the adoption of the commissioner system, in which the direction of public works is entrusted to a small committee of experts appointed under conditions which render it difficult to overrule or dismiss them. We believe that this plan was first adopted in connection with the State Railways in Australia, and proved of great service in preventing the construction of unremunerative lines under political pressure. In America and Canada the plan has also often proved highly advantageous, but according to Mr. Waddell a tendency quickly developed to make the appointment political, with the result that the last state of things has been worse than the first. Where the system has been fairly worked, however, excellent results have been achieved, and in some American cities at any rate, it is frankly acknowledged that the control of many public departments by engineers has been of very great advantage to the community.

A serious obstacle to the engineer playing a more pronounced part in public affairs lies in the little interest taken by the public in the details of his work. When things go smoothly the success by which the public benefits is the only recompense of months or years of hard thinking. When difficulties arise it is commonly the practice to suppress all mention of them, even after they have been surmounted. Nevertheless, many dramatic moments arise in engineering operations which, if skillfully recorded, might help to raise the profession in the public estimation to something like the prominence now accorded to that of the law.

The general public, for example, is wholly oblivious of the devotion and courage shown in the earlier days of electric lighting by the engineers in charge of our power stations. Wellington never longed more earnestly for night or Blucher than did the station engineer for the time when the fall in the day's demand would allow him to cut out some machine which had unexpectedly developed faults, threatening at each moment a catastrophe, but kept running with a man stationed at the stop valve in the hope that "she'd last out over the peak." A most dramatic tale could be told of how the late Mr. Bryan fought to save the filters of the East London Waterworks Co. from a sudden flood on the Lea. Men were obtained anyhow or anywhere to build up a protecting dam faster than the rising water. A brick yard was raided to supply the materials, and brick by brick the wall was raised. It was only after hours of anxiety that the flood began to fall and the security of the filter beds was assured. Had they been flooded the consequences might well have been an epidemic of typhoid. All protective measures had to be taken on the sole responsibility of the engineer, who incurred expenses running into hundreds of pounds without appeal to the directors. It is a curious commentary upon the public appreciation of the standing of its engineering experts that when appointed chief engineer to the Metropolitan Water Board Mr. Bryan was prevented by the regulations from expending any sum exceeding £5 without first obtaining the sanction of the Board.

Utilization of Sludge

Editorial in The Surveyor, London, Feb. 11, 1921.

Investigations of the possibility of recovering the nitrogen in sewage for the benefit of agriculture have hitherto been confined to this part of the world and America. We now learn that experimental work in connection with this subject is being carried out in the Far East, particularly at the Indian Institute of Science, Bangalore, where Dr. G. J. Fowler, F.I.C., formerly of Manchester, is directing operations. The December issue of the Journal of this institute contains a paper by Dr. Fowler, on "The Conservation of Nitrogen with Special Reference to Activated Sludge," a subject upon which, as our readers are aware, he is specially qualified to speak. The main part of the paper deals in considerable detail with the sources of nitrogen, methods of sewage treatment, chemical changes in nitrogenous organic matter, nitrogen fixation, the nitrogen in activated sludge, and green manures. Especially interesting is a series of photographs showing the methods employed for collecting night soil in Shanghai and applying it to agriculture. Dr. Fowler points out that this process, though sound scientifically and economically, is of a very unsavory description, and the problem presented is to attain the same economic results without offensive accompaniments. It should be noted that in stating in conclusion that the activated sludge process offers the possibility of the recovery for agricultural purposes of all the nitrogen in town sewage, Dr. Fowler assumes that the nitrogen in the effluent as well as that in the sludge can be economically utilized. This would mean the provision of large areas of suitable land for the irrigation of the effluent and the cultivation of saleable crops. While this would be difficult, if not impossible except in a few places in this country, it may be quite feasible in India, and it is in countries of this character that the greatest benefit from the utilization of the nitrogen in sewage may be derived. Dr. Fowler's paper is a very valuable contribution to the literature of this subject, and should serve as a stimulus to further research work in other parts of the world.

The British Government's Severn Tidal Power Scheme

Editorial in Engineering, London, Dec. 3, 1920.

Strange as many official actions are now-a-days, few have struck us as so singularly out of place as the manner in which the country was informed last week of the proposal to embark upon a large tidal power scheme on the Severn. We are not so much concerned for the moment with the scheme itself, whatever merits it may ultimately prove to possess, as with the method which the Ministry of Transport has seen fit to adopt in connection with a matter of great weight and high technicality. The tone of the curious document which issued from this Ministry, dilating on this scheme, made us turn over its pages mechanically, as one would with a company promoter's prospectus, to find out how much capital it was intended the project should swallow up. Our search was not attended by success. Neither could we discover therein a particle of technical data, nor yet the name of any responsible person attached to it. In fact, apparently beneath the notice of His Majesty's Printers, the notes distributed seem to have been considered by the Ministry itself, only fit for some office duplicator in Whitehall Gardens.

In highly speculative circles, the subtle creation, in advance, of a favorable impression is not infrequently indulged in, but the custom has been so often associated with the less reputable side of finance that it is seldom countenanced by self-respecting concerns, and its use is therefore almost sure to arouse suspicion. That the official language adopted in this extraordinary case is also likely to discredit the department concerned may be gathered from a few quotations, for it suggests that someone has settled in Whitehall whose office should properly be in the purlieus of the city. We find, for instance, this composition headed, "The World's Greatest Water Power Scheme," "The Gate of the West," "A Paying Proposition," while, on dipping further into it we are told that this is "the first scheme . . . to utilize the rotating forces of the earth," and "to snatch part of the movement of the earth and put it into gearing to turn machinery." It is said to be planned on a "sound economic basis" and to offer "limitless vistas," "bringing the blessings of Light, Purity and Power within the reach of all classes of the community." Such extravagance of language is altogether at variance with what one would expect from the dignified and careful deliberations of a responsible Government Department. One can only conclude that this clap-trap is designedly intended to convey to the public the idea that the Ministry is vastly alive, and immensely busy with wonderful and original reforms.

The careful avoidance of all technical data in this document, while at the same time specious reference is made to engineering points in a manner clearly intended to clothe the whole with an air of verisimilitude well calculated to impress a credulous public, indicates the standard of intellect to which this Ministry thinks it best to make its first appeal. It cannot, however, be congratulated on having, in any sense, added luster to its office by this performance.

It will be time enough to consider the scheme itself when the promoters see fit to back it with estimates of cost. Several days have now passed, but no endeavor has been made to supply even a rough estimate of this. At present it is only possible to surmise that the project requires plant of a capacity of about four times the normal load of 500,000 HP. Everything cnnected with it is described as either "immense," "gigantic," or "enormous," including the dams, pumps, etc., to say nothing of the 40-ft. tunnel for the water for the "great inland lake." An "army" of men running into thousands of all grades, for many years would be employed, and so, whatever happens, we may be fairly sure that the cost, too, would be colossal. We can hardly get away from that fact, and it is very doubtful if the present is at all a suitable time for further national expenditure. It looks very much as if the whole thing were intended to be something in the way of a political reply to the oft-repeated charge made against the Government of extravagance and waste. With the country becoming weary of heavy national expenditure, the Ministry would, we believe, be well advised in placing their facts, whatever they may be, before the country, when we are inclined to think that if the scheme should prove attractive after careful scrutiny, it might be left to private enterprise. We believe it to be the unfortunate fact that such projects do actually come within the all-embracing Ministry of Transport Act. The whole affair has a very ominous ring about it, suggesting that decisions have already been arrived at. The reiterated use of the definite words "is" and "will be," in the description of the plans, in place of the more problematic "would" or "could," would almost indicate that the work is even now in hand. We trust that the Ministry has not abused its trust so far as that, but after this exhibition of the treatment it thinks suited to national questions and responsibilities we are almost inclined to despair of it altogether.

Since the issue of the unfortunate document which we have felt it our duty to criticise above, the Ministry has disclosed something more of its plans. In the House of Commons, Sir Eric Geddes has stated that the scheme would find employment for 10,000 men for seven years. We leave it to our readers to make the simple calculation what the cost of labor alone would therefore be at present rates of wages. Further, yesterday we received from the Ministry a document, for some reason marked "Unofficial," giving a few details of the idea in a considerably modified tone, but still lacking many of the main technical essentials, and especially the all-important particulars of cost.

From this document we learn that it is expected to utilize the barrage turbines for 7 hours with heads varying from 5 ft. to 30 ft., the latter occurring only, of course, at spring tides. The machines would generate 1,300 kw. each, which, for the normal load, and without the surplus plant to meet the demand for pumping, suggests that there will be quite a number of these units in the barrage installation. We note also that the suggestion is made that 500,000 kw. can be transmitted to London; at the same time it can all be consumed in South Wales, or in the Birmingham district, a point on which clearly some decision must be arrived at or the cost of the longer transmissions will offset any object in supplying distant markets. The dynamos at the dam will be variable-speed generators, producing direct current at a constant voltage of 525 volts. The turbine speeds of approximately 40 r.p.m. to 80 r.p.m. will be geared up to give 300 r.p.m. to 500 r.p.m. for the generators. The direct current will be converted to alternating at 330 volts by rotary converters. Static transformers would step this up to 60,000 volts for transmission to the industrial centers, etc., which it is proposed to supply. When excess power is produced at the dam it will be transmitted to the pumping station 10 miles distant, where it will be consumed in pumping water up to the inland lake. At this pumping station the plant proposed consists of pumps, turbines and motors arranged for use also as generators, in order to reduce the installation as far as may be, the plant being capable of a peak output of 1,000,000 HP. It will therefore be seen that the amount of machinery will be very considerable indeed.

It is claimed that in the scheme the only machines not running always at full load will be the dynamos at the barrage, but as these will run into several hundreds, the conditions under which they work will constitute an important factor. The units at the pumping plant are planned at 13,000-kw. machines working at 2,200 volts and 375 r.p.m. The head under which the turbines here would work, and against which the pumps would have to operate is not given, but the tunnel, 40 ft. in diameter, is said to be about a mile in length through rock.

It will be clear from the labor cost, the multiplicity of units at the dam and duplication of the plant at the pumping station, the cost of tunnelling, etc., to say nothing of the dam itself, and the separate railway and road viaduct, with the locks and lock machinery, that the scheme would run the nation into vast expenditure to attain results which are by no means certain to secure a profitable selling price for the current generated.

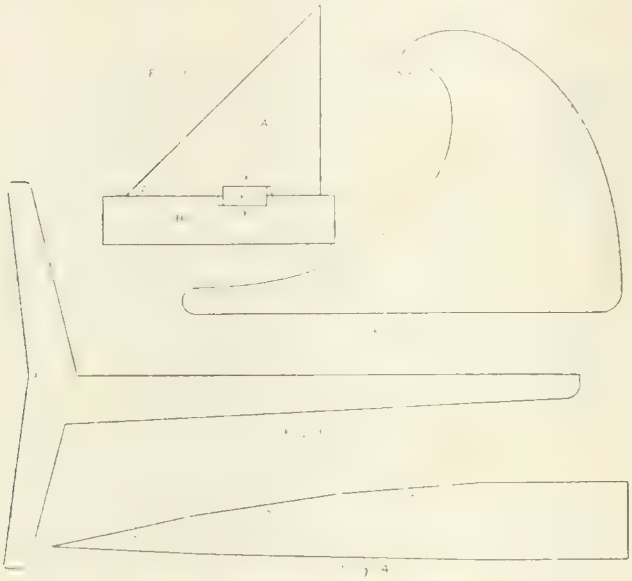
English Mason Lays 1,555 Bricks Per Day.—John Laing & Son, building contractors, of Carlisle and London, in a letter in the Builder (London), state that "on a building contract we have in hand one bricklayer has laid 28,000 bricks in 18 working days—an average of 1,555 bricks per day. Further, the quality of the work is excellent."

Some Useful Drawing Implements

From The Engineer, London

There is a considerable body of men working at the drawing board who have a decided aptitude for contriving new methods of facilitating their work, such, for instance, as specially graduated slide rules, detail steincils and so forth To them the devices described below, which have been designed by Mr. J. St. V. Pletts, of Marconi House, Strand, will appeal strongly, while even the most old-fashioned draftsman will appreciate the merits of the template shown in Fig. 2, which, with the assistance of a piece of thread and a few pins, will replace a whole set of French curves and produce a more workmanlike result.

Perhaps the most tedious part of an engineering drawing, and the one in which any little inequalities are most conspicuous, is the hatching of sections. A very simple device for drawing such lines rapidly and accurately is shown in Fig. 1, where A is a set-square with a slot of length X in one side, B a straight-edge—or another set-square—with a slot of length Y in one side, and P a rectangular piece of shorter length fitting into the slots. If B is slid along A and then A along B as far as the piece P will allow, the spacing of the lines ruled against the diagonal edge of the set-square will be the difference in the lengths of the slots and the piece P multiplied by the sine of the set-square angle.



Devices for Facilitating Drafting.

The piece P can, of course, be fixed to either A or B, in which case the spacing is fixed; but the former arrangement has the advantage that the piece P is easily changed, so that several pieces of different sizes may be made in order to give different widths of hatching, and—if the same ruling edge is always used—may be marked with the spacing.

The device shown in Fig. 2 depends on the principles of the logarithmic spiral, the value of which in drawing curves is set out in Legros and Grant's book, "Typographical Surfaces." It comprises a template, the two edges C and D of which are both logarithmic spirals, but one is turned through a right angle relatively to the other, so that C becomes the evolute, or locus of centers of curvature, of D. The result is that if any part of the scale D be fitted to a portion of a curve, the same part of the scale C will be the evolute of that portion, and may be ruled off, the complete evolute of any curve being thus easily and quickly drawn. As a pencil tied to a string which is wrapped on the evolute will describe the original curve, it is obvious that, with the aid of a few pins stuck into the evolute—or a little on the convex side of it—the curve may be drawn in a single sweep. A pencil point can, of course, be put through a loop in the end of the string, but an ordinary drawing pen can be used if a little ring for the attachment of the string is fixed on close to the point. Such a pen may also be used for drawing elipses by means of a string attached to the two foci and running through the ring.

In perspective drawings it is often necessary to draw radii from a distant center, and a centrolinead, or Y-shaped ruler, slid along two pins placed against the two arms, is well known for this purpose. If p is the distance between the two pins and α the angle between the two arms of a symmetrical Y, then the perpendicular distance of the center of rotation from the middle of the line joining the two pins is:

$$c = \frac{1}{2} p \tan \frac{\alpha}{2}$$

If, therefore, instead of the usual adjustable arms, a fixed Y is employed, the distance c becomes a simple multiple of the distance p. In Fig. 3 such a ruler is shown having two values of α, which make c two and four times p, respectively.

For drawing the graticules of some kinds of maps, arcs from a distant center are sometimes required in addition to radii, and for this purpose a similar instrument, but without the ruler extension and with a pen or pencil fixed at the point of the angle α, is useful. But in this case α must be determined from the formula:

$$r = \frac{1}{2} p \operatorname{cosec} \alpha$$

because it is the radius of the arc—not the distance of the center from the middle of the chord—that is usually wanted. Unless, however, this instrument is to be used for a very smal range of radii it is much more useful with an adjustable angle, which destroys its simplicity and therefore takes it outside the scope of this article.

Finally, a simple little instrument, which, for many purposes, is to be preferred to the ordinary small semi-circular protractor, is shown in Fig. 4. In this the angle in degrees between any two edges on opposite sides of the rule is the sum of the numbers with which they are marked, so that every degree from 0° to 15° can be obtained. It follows that with the aid of an ordinary 30-60° set-square every degree of the entire circle can be obtained with a ruling edge, which the ordinary protractor does not give.

Disposal of Sludge on Lands as Fertilizer

By JOHN E. FARMER.

From The Surveyor, London, Dec. 17, 1920.

I give the following in the hope that it may be the means of giving thought to the possibilities of a sludge disposal on land as a cheap nitrogenous fertilizer. When sludge is exposed to the air it undergoes oxidation, and from results of a laboratory experiment, there need not be any loss of nitrogen, but a possible increase.

If sludge is treated as sewage is treated in the activated sludge process, I find from laboratory experiments that the sludge odor, after a certain degree of aeration, is altered to an earthy smell, and without loss of nitrogen. Having disposed of 30,000 tons per year of fresh sludge, 6 per cent solids, for some years, I have been able to note the good and the bad points of such a method of disposal. One objectionable point to the spreading of fresh sludge in a thin layer over the surface of the soil is the sludge odor. To overcome this I have used lime with some beneficial result, but not to the extent I should like. I believe the treating of the sludge on the lines as mentioned above would overcome this objection, and also have other beneficial effects. Another objection is the plowing in of the sludge soon after application. If the method was taken up for the land disposal of the sludge after aeration, agricultural engineers would soon devise a means of plowing in of the sludge without horses or a man having to wade through it.

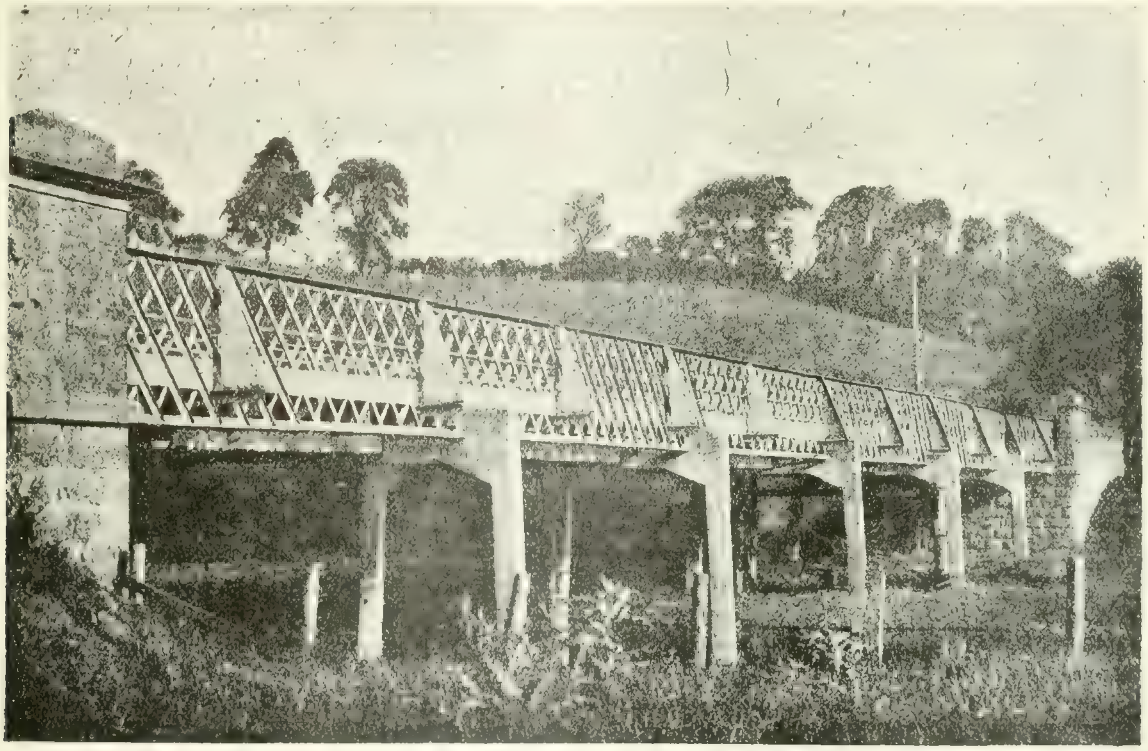
Comparative cost of nitrogen units delivered onto the land must be taken into consideration when advocating sludge as a manure. Aerated sludge could be cheaply pumped some distance to land requiring it, and the weight of nitrogen per acre at the rate of 75 acres sludged per year for 160,000 persons, is approximately 15 cwt., or equal to that in about 100 loads of farmyard manure. The sludge from the population of 7,000,000 draining to the London County Council works, at the above rates would give to 4,300 acres, each year, approximately 15 cwt. nitrogen. Half this weight with the aid of mineral manures, would be manuring on intensive lines.

Reconstruction of Lattice Girder Bridge in Reinforced Concrete

From The Surveyor, London, Feb. 18, 1921.

Originally designed for light country traffic, the bridge, which carries the highway from Rothbury to Harbottle, Northumberland, England, over the River Coquet, was 183 ft. long with a roadway 15 ft. wide, and was formed by two wrought-iron lattice girders carried at each end on masonry abutments, and two river piers, each consisting of four wrought-iron screw piles with suitable bracing, making a center span of 73 ft. and two end spans of 55 ft. each. The decking was of timber carried on wrought-iron joists and surfaced with road metal.

Some 10 years ago one of the two iron piers was broken and carried away by some large trees which came down with an exceptionally heavy flood, and was replaced by a timber trestle. During the late war the Timber Production Department of the Ministry of Munitions felled a large number of trees in the woods around the village of Harbottle, and, in hauling these over the bridge, did considerable damage to the structure, which was quite inadequate for the heavy loads thereby involved.



Sharpeston Bridge, Northumberland, as Reconstructed in Reinforced Concrete.

Being faced with the necessity of making good the damage caused, Mr. J. A. Bean, the county surveyor, realized that in a short time this and other country bridges in Northumberland would be called upon to carry much heavier loads in the future than in the past. He therefore decided to have Sharpeston bridge rebuilt sufficiently strong to carry a load of 25 tons on four wheels, and decided to adopt the reinforced concrete form of construction.

The bridge, as it now stands, consists of a reinforced concrete decking 7 in. thick, carried on two longitudinal beams 10 in. broad by 20 in. deep, which take bearing on reinforced concrete templates let into the old masonry abutments, and are connected laterally by five transverse beams 12 in. broad by 26 in. deep, which are carried on 10 ferro-concrete piles, 12 in. square, driven to a batter of 1 in 15 to do away with the necessity of bracings. The original lattice girders were left in position and now form the parapets—an economical method of utilizing the old ironwork. There is now no road metal on the bridge, the reinforced concrete decking being covered simply with a thick coat of tar and sand.

The new bridge, designed by Mr. Bean, was constructed under his supervision by Purdie Lumsden & James, Ltd., of Newcastle-upon-Tyne, in accordance with the Mouchel-Hennebique system, and with the working drawings furnished by L. G. Mouchel & Partners, Ltd., of Westminster, England.

Method of Driving River Dee Tunnel Through Water Bearing Strata

From The Times Engineering Supplement, London, February, 1921.

In the course of a paper on tunnelling through water-bearing strata, read before the Liverpool Engineering Society, Mr. R. F. Baker gave an account of the construction of the tunnel by which the aqueduct of the Birkenhead Corporation from Cerrig-y-Druidion passes under the River Dee at a point nearly ¾ mile below the Hawarden swing bridge on the Great Central Ry.

The work comprised the driving of a tunnel 8 ft. in internal diameter between two cast-iron shafts 13 ft. in internal diameter, sunk 759 ft. apart from center to center. The tunnel is on a gradient of 1 in 107 falling from the Welsh to the English side, and its top is about 12 ft. below the deepest part of the channel. It was designed to take two lines of pipes, 25 in. in diameter, one of which has been laid.

Shafts.—The two shafts are similar in construction and differ only in depth. That on the English side measures 69¼ ft. from the top to the cutting edge, and that on the Welsh side 60¾ ft., the actual depth of the cutting edge below the ground surface being 57 ft. on the English side and 45 ft. on the Welsh side. The methods employed in sinking the two were identical. In the shaft on the English side a timbered excavation was taken down to about 6 ft. below the surface of the ground to just above the water level. The amount of water soon rendered grabbing necessary, and the last 7½ ft. of the sinking was effected by compressed air.

Pressure Regulation.—The river at the site of the tunnel is tidal, the water level varying from about 4 ft. above datum at low water to 16 ft. at high water of spring tides. The tide rises suddenly in the form of a bore at the spring tides, passing up the river at about eight knots, and high water is attained approximately one hour after the bore has passed. Low water occurs some four hours after high water, the tide ebbing at the rate of about 12 knots. The rise and fall of the tide is irregular and depends upon the direction and force of the prevailing winds.

A tide gage, marked in feet above ordnance datum, was erected, and a board was fixed in the engine house having parallel columns of figures, the one giving the level of the tide in feet above ordnance datum, and the other the pressure required to balance the hydrostatic head calculated to a depth of 2 ft. below the axis of the shield. A sliding indicator attached to the board could be fixed in any desired position to correspond with the height of the tide as observed by the gage. The engine drivers had to maintain the air pressure strictly in accordance with the figures shown by the indicator, but the foreman in the tunnel was permitted, if necessary, to give instructions to increase the pressure to a maximum amount of 1 lb. above the indicated pressures. The maintenance of the air pressures at the proper level is a very important point, as any excess pressure would be very likely to cause a "blow" at the face. If the pressure fell below the required amount, water would immediately appear in the invert of the tunnel. When tunnelling was started it was found that there was a lag of about one hour in the tidal effect upon required pressures in the tunnel, and the indicator in the engine room had to be altered to allow for this. The lag gradually decreased as the tunnel advanced, and it did not exist under the channel

Shield.—The strata to be dealt with throughout the tunnel consisted of very fine sand charged with water directly beneath the tidal river under a head of about 42 ft. at high water, and the hooded shield was therefore adopted as the best form for carrying out the work. The cutting edge at the top extended 1 ft. 6½ in. beyond the cutting edge at the lowest point of the invert. This formed a projecting hood or chamber in which the miners could work in safety, and it enabled the material to be entirely removed from the lowest part of the invert, so that the shield could advance easily, and there was no danger of the cutting edge being deformed by contact with boulders or other obstructions.

The diaphragm was formed of ¾-in. steel plate with an opening 4 ft. 8 in. by 3 ft., the upper portion of which was closed by a steel door and the lower portion by planks fitting in grooves; there were also four holes 6 in. in diameter through the diaphragm clear of the opening, to enable tubular struts to be used to support the face when shoving with the shield entirely closed. The shield was pushed forward by means of six hydraulic rams 7 in. diameter and 22 in. stroke; the pressure was supplied by a hydraulic pump working in the tunnel connected to the shield and driven by high-pressure air. The tunnel was built up of cast-iron segments 20 in. wide, seven segments and one key forming a complete ring.

The clay-pocketing system was adopted throughout. In this system pockets 22 in. in length are scraped out ahead of the cutting edge of the shield, the top of the hole being about 2 in. above the level of the cutting edge of the hood. In open material the pockets are usually 12 in. to 15 in. wide, but in the sand which was met with in this tunnel it was possible to make them considerably wider. As soon as the hole had been excavated, it was at once filled in with tempered clay; another hole was then formed on one side of the first hole and clayed up in a similar manner, and so on until the ring of tempered clay had been formed three parts of the way round the circumference. When the shield is pumped forward the cutting edge of the hood enters the clay pocket and a skin of clay is left over the top of the shield. This clay remains in position as the shield advances, and prevents the escape of air at the tail of the shield; the compressed air supports the clay until the grout is put in, and no disturbance of the ground above is caused through settlement.

Progress of Tunnelling.—Tunnelling was begun on Nov. 24, 1919. The working week started at 10 p. m. on Sunday night and finished at midday on Saturday, and was divided into 10 shifts of 12 hours and two of six hours each; there were two intervals of one hour each for meals in each 12-hour shift. Once the tunnel was started excellent progress was maintained for several weeks. It was always realized that there was a possibility of a "blow," but as the tunnel was being driven on a downward grade, it was decided to take the risk rather than introduce restrictions which would very materially reduce the rate of progress and increase the cost. For several weeks down to Feb. 10, 1920, the progress averaged 33 rings per week, equal to a length of 55 ft., but on that date, when the shield had just started to be shoved for ring No. 279, a "blow" occurred in the face and the tunnel was partially flooded. When the "blow" occurred the air pressure in the tunnel was 15 lb. per square inch, and it immediately dropped to 9 lb. The water rose in the tunnel to the level of the top of the opening in the diaphragm, and a considerable volume of sand also found its way into the tunnel near the face.

Soundings taken in the river over the site of the "blow" showed that a crater had been formed measuring about 12 ft. in diameter and 4½ ft. deep. This hole was filled with clay, and then the water in the tunnel was carried to the surface by means of the "snore" pipe, and the sand was removed. As soon as the sand had been removed up to the diaphragm of the shield, the door was closed, and the rams and shield pump and all connections were overhauled before starting work again. The actual work of filling in the crater in the river and removing the sand from the tunnel occupied less than a week, but a further delay of two days occurred owing to the unreasonable demands made by the miners, which had to be settled before they returned to work.

Work was resumed on Feb. 19, and it was decided that until the channel of the river had been passed the diaphragm of the shield should be closed while shoving. Tabular struts were therefore used, passing through the holes previously mentioned, in place of the raking struts. For additional safety, the length of the excavation was reduced so that the vertical face was always kept well inside the hood of the shield, and two shoves were made for each ring of iron. This procedure was carried on for 133 rings, and the progress during this time averaged just over 16 rings per week. For the remaining 37 rings the method of shoving for the full length of one ring at a time was adopted, and the cutting edge of the shield reached the shaft on the English side of the river on April 27. The shaft at this time was standing full of water, and by drilling two holes through the bulkhead plates the water was drawn out of the shaft into the tunnel and passed to the surface through the "snore" pipes. When this had been done the bulkhead plates were removed and the shield was shoved forward into the shaft, the rings in the tunnel being built as it advanced. The shield was then dismantled and the cleaning out of the tunnel was proceeded with. By June 14 the caulking of the joints and grummeting of the bolts had been completed, and the air was finally released from the tunnel on that date.

Cost.—The men employed inside the tunnel to form a working gang consisted of one ganger, two miners, two miners' laborers, three laborers filling in and running out, and one hanger-on. The men were paid the ordinary day-work rates prevailing at the time plus a bonus for every ring erected over an agreed number per week. This method ensured the maintenance of the maximum rate of progress.

In round figures the cost of constructing the two shafts and tunnel, not including the laying of the pipes, was £36,000 ($179,000). The cast-iron lining for the shafts and tunnel cost just over £7,000 ($34,000). As wages and prices of materials were constantly rising during the construction of the works, these figures cannot be taken as a reliable guide to the cost of similar works at the present time. The pre-war price for the construction of the tunnel alone amounted to £58 11s. 3d. ($282) per lineal yard, so that the cost of the tunnel 751 ft. long would have been £14,660. The sinking and lining of the shafts would have cost about £3,400 at pre-war rates, making a total of, say, £18,000, compared with the figure of £36,000 which the work actually cost. The works, designed by Sir Alexander Binnie, Son, and Deacon, of Westminster, were carried out by Messrs. John Cochrane & Sons, and formed part of contract No. 3 of the Birkenhead Corporation Waterworks, on which the author was resident engineer.

Comparative Labor Figures on Road Tarring.—In an article in Municipal Engineering (London) of Sept. 20 last, Julian Julian, Borough Surveyor, of Cambridge, gives the following comparative figures on tarring roadways in 1914 and 1919:

	1914.	1919.
Prevailing rate per day	3s. 8d.	8s. 10d
Equivalent days worked	515	560
Square yards of tarring . ..	280,729	317,736
Square yards per man per day	545	568
Gallons of tar used .. .	37,357	64,180
Gallons per man per day	72	115

It will be seen that the area of tarring done for a day's work in 1919 was slightly more than in 1914, while if the work is to be measured by the amount of tar used the day's work was very much more. The manual labor depends mostly on the area, but to a small extent on the quantity of tar and other materials used.

The Conservation of Nitrogen with Special Reference to Activated Sludge

By GILBERT J. FOWLER,

From the Journal of the Indian Institute of Science, Bangalore, India, December, 1920.

In the foregoing pages evidence has been given to show (1) that by the scientific and economic use of waste nitrogenous material and also of green manures the necessary nitrogen for the supply of the world's agriculture can readily be obtained.

(2) That very large populations are adequately supported in many parts of the world, particularly in China, without the need for the nitrogen of artificial fertilizers.

(3) That inorganic nitrogen in the form of nitrate, sulphate of ammonia or calcium cyanamide, even when combined with other mineral nutrients, such as potash and phosphoric acid, is not alone adequate for healthy plant development.

(4) That minute quantities of accessory food materials, elaborated by bacterial action, and which have been termed auximones are necessary if vigorous plant life is to be sustained.

(5) That these products are only to be found in organic manures.

(6) That among organic manures activated sludge has been found to give the most striking results.

(7) That, provided the nitrogen in the sludge and effluent can be economically utilized, the activated sludge process of sewage purification offers the possibility of the recovery for agricultural purposes of all the nitrogen in town sewage, as not only is there no loss of nitrogen in the process, but an actual gain owing to the occurrence of nitrogen fixation.

In order that the best results may be obtained from organic nitrogenous manures, further research is required in numerous directions, which are briefly indicated in the following paragraphs.

The various lines of investigation may be classified broadly under:

(a) Laboratory experiments, including pot or water cultures.

(b) Field experiments.

(c) Technical experiments.

Laboratory Experiments.—Experiments on the purification of special trade effluents by activated sludge as well as general experience would indicate the possibility of building up activated sludges capable of bringing about specific bio-chemical changes at a greater velocity than is possible by the usual less intensive methods of bio-chemical activity. The acceleration of nitrogen fixation in this way is a peculiarly attractive problem, it being now unquestionable that fixation does take place.

It will be necessary in the first place to determine what proportion of this nitrogen is fixed in the soluble or insoluble condition, whether, e. g., complex nitrogenous slimes are formed directly, or whether simpler and soluble nitrogen compounds are first formed and are afterwards built up into more complex bodies. It may well be that the advantages of symbiosis of different organisms, pointed out by Bottomley, Richards, and other workers, are due to a difference of function in this respect.

It will then be to determine whether by suitable choice of carbohydrate food, of the necessary symbiotic organisms and by the maintenance of proper temperature conditions, it may be possible to build up a special activated sludge which will fix nitrogen in quantity and at a rate sufficient to make the process one which might compete with electro chemical or thermo chemical plants.

It is evident that the bio-chemical changes brought about in organic nitrogenous matter such as activated sludge by the agency of the bacteria present in it will be greatly modified by the activity of the roots of the growing plant.

This is clearly brought out in Harrison and Subramania Aiyer's work, referred to in the section on green manures. It would seem likely that the withdrawal by the growing plant of the products of bacterial activity in the nitrogenous matter would stimulate further production of these, so that the maximum rate of change takes place under conditions when both plant and bacteria exert their maximum efficiency.

The possibilities of loss of nitrogen by purely chemical action or by a combination of bacteriological activity and chemical change afford an extensive field for inquiry. The interaction of complex amino compounds and nitrites in presence of nascent hydrogen or carbon dioxide can be studied in almost unlimited permutations and combinations of interest.

A further problem in this connection will be to find how far such loss is diminished or inhibited in the presence of the growing plant or of nitrogen-fixing organisms. The fact of there being no loss of nitrogen in the activated sludge process would indicate that the activity of the nitrogen-fixing organisms may mask a certain amount of denitrification change, as in the activated sludge tank there is considerable evolution of carbon dioxide in presence of the products of the breaking down of proteid matter, together with nitrites and nitrates, a condition of things under which loss of nitrogen might be expected.

The conditions of loss of nitrogen from green manures and from ordinary manure heaps are still somewhat obscure in spite of the considerable amount of study which they have received. The experiments with amino derivatives of known composition just referred to should throw some light on the decomposition of the complex proteids of green and other manure.

The possibility of the economic conversion of ammonium salts into nitrates through the agency of activated sludge has been referred to, and experiments are already in hand by Mr. M. B. Roy under the writer's direction at the Indian Institute of Science.

The precise conditions for the most advantageous use of nitrolim are not fully understood, and it will be of use to make a careful study of the possible transformations which may be effected in this substance by bacteriological agency. A knowledge of the changes which may take place in a mixture of this substance and activated sludge may lead to a useful combination of the artificial nitrolim and the different varieties of organic manures.

Field Experiments.—The trials already made with activated sludge and ordinary crops should be extended and, in particular, selection made of such plants as respond most readily to the stimulus of this manure with a view to discover the possible reasons for this response. The effect of mixtures of activated sludge with other manures such as superphosphate and basic phosphate should be studied.

Important Indian crops which respond to nitrogenous manure, particularly indigo, sugar-cane, and paddy should be manured with activated sludge and the effect noted.

The "availability" of the nitrogen in the sludge when the latter is put on the ground in the wet state as compared with the results when the sludge is dried for transport should be determined both by laboratory and by field experiments. Experiments by Mrs. Mumford and by Mr. Ernest Gaul have shown that the lower the temperature of drying the more immediately "available" is the nitrogen, while the nitrogen in the wet sludge is the most quickly "available" of all.

Accounts occasionally appear in the Press of extraordinary profits, up to, e.g., £1,000 per annum per acre, made by intensive culture of market produce, etc. Experiments on these lines might well be made with activated sludge. Possibly a kind of hanging garden could be constructed over an activated sludge tank on the principle of the laboratory experiments described to produce quick growing and succulent crops for the market, such as lettuce, onions and tomatoes, peas and beans, as well perhaps as special flowering plants which have shown themselves responsive, such as lilies and hydrangeas.

The Chinese are accustomed to produce succulent crops by intensive cultivation, as these show the quickest response to manure, are easily digestible, and may have a relatively higher nitrogen content than fully-matured crops. Moreover, the same plot will produce more crops in a given time.

The scientific study of fishponds fed with the effluent from activated sludge installations should reveal the life cycle best suited for the growth of fish and the recovery of nitrogen thereby. Thus it may be anticipated that aquatic plants will thrive on the nitrates and other salts present, infusoria of various kinds will feed on the bacteria and will afford food for fish, and both fish and plants will be a source of nitrogen for subsequent return to the soil.

The writer in the past once made some attempts with an effluent of a moderate standard of purity to establish a small fishpond, but fungoid growth made their appearance, and the conditions of a healthy life cycle were evidently not present.

The absence of colloids in an effluent properly purified by activated sludge, as well as the high content of dissolved oxygen either present or readily obtained, should greatly facilitate the possibility of maintaining suitable conditions for fish culture.

Technical Experiments.—The most important technical problem to be solved in connection with activated sludge, as distinguished from those directly connected with bio-chemistry or agriculture, is undoubtedly the drying of activated sludge for transport. Activated sludge fresh and in good condition is a highly-flocculent precipitate which readily settles and is easily drained from superfluous water, but the resulting mass is very gelatinous and contains over 90 per cent of water. The problem is therefore the economic "dewatering" of this jelly. In view of the results published and the numerous patents taken out in connection with the dewatering of peat and of kaolin, etc., electric endosmose seems a very attractive line of attack. Recent laboratory trials by the writer and Mr. Malandkar with gelatinous precipitates of alumina would tend to confirm the conclusion arrived at by workers in Manchester that with such material any effect apparently due to electric endosmose is, in large measure at any rate, produced by a rise of temperature. Even if this be so, it would indicate that a very moderate rise of temperature will tend to separate water from the jelly.

Moderate heating, therefore, combined with centrifugal action in one of the several continuous centrifuges described in various recent papers and patent abstracts, e.g., in the Journal of the Society of Chemical Industry, is likely to reduce the water content of the gelatinous activated sludge to such a point that it can be economically dried by direct methods.

The final process of drying will need to be scientifically conducted, as not only will excessive or too rapid heating tend to harden the albuminoid matter present and render the nitrogen less readily "available," but the bacterial life present in the sludge and necessary for its maximum efficiency will also be destroyed.

It is probable that warm air in large volumes will be the best drying agent. Many tons of humus tank sludge have been dried in this way at the Davyhulme works of the Manchester Corporation, and the method is being used at a recently established factory in Madras for the purpose of drying glue.

During the hot weather in Indian and other tropical countries no difficulty should arise in drying the material in ordinary well-constructed sludge drying beds in the open air as the sludge is inoffensive in character.

If the bacterial factor in the sludge is neglected and its value simply calculated on the units of nitrogen present, more drastic procedure is possible. In this connection the conclusions so far reached by the city of Milwaukee are of interest. After several years of large-scale experimental work, in the earlier stages of which the present writer was professionally consulted, a complete scheme has been devised to treat the whole of the sewage by the activated sludge process at an ultimate cost of £1,000,000. The methods decided upon for conversion of the sludge into fertiliser are briefly as follows: The sludge is somewhat concentrated in the treatment tanks by subsidence, and removal by means of special sludge ploughs known as "thickeners." As it leaves the tanks it contains 97.5 per cent moisture, 4.5 cc. of sulphuric acid are added per gallon of sludge, which is then pressed in filter presses of specially selected design to a moisture content of 80 per cent. This pressed sludge is then dried in mechanical driers of normal type. It is estimated that the dried sludge containing 10 per cent of moisture will be worth at least £3 10s. per ton.

If this sludge is to be used in soil already containing a full supply of the necessary bacteria, its complete or partial sterilization may be of small moment. Where it is to be applied to poor soil the admixture of a certain proportion of sludge dried at a temperature which will not destroy the necessary bacteria will probably greatly enhance the value of the manure.

[illegible] the East and [illegible] in towns where the rateable value is low compared to the population, a large consumption of water per head for the purpose of transporting sewage is not available, and so the liquid to be dealt with is likely to be very concentrated. In many cases it is necessary to "dump" excreta, etc., removed from the houses in pails by hand direct to the sewers. The conditions for successful treatment of such material by the activated sludge process have not yet been fully investigated.

Among the many lines of work shortly to be undertaken in Shanghai, this question will receive attention, and an installation is to be fitted up in connection with a latrine which can be kept under exact control. It may well be found that the sewage will have to be diluted in the initial stages with extra water, and afterwards with its own effluent on the principle which was adopted by the writer several years ago in dealing with highly concentrated and germicidal trade effluents.

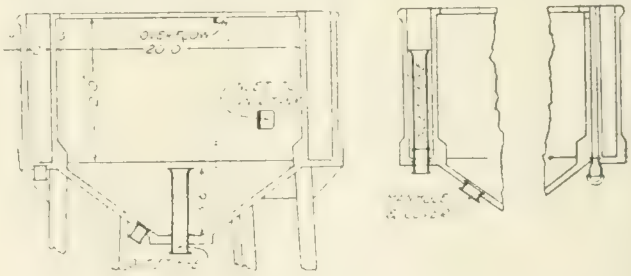
It is evident that much work still remains to be done in the large field of inquiry which forms the subject-matter of the present paper. Success can only be achieved by correlating the results of the activity of many workers, investigating different aspects of the subject in different parts of the world. The labors of the bio-chemist, the bacteriologist, the botanist, the agriculturist and the engineer will all be needed. Such work, however, will be well worth while if it results, as there is every reason to hope it will, in an increase in the productivity of the soil, and a consequent great addition to the real wealth of mankind.

2-Compartment Reinforced Concrete Water Tower

From The Surveyor, London, Feb. 25, 1921.

Although generally resembling some of the numerous ferro concrete structures of the same class which have been built all over the United Kingdom, a water tower which was completed last year for a Gravesend firm embodies one or two distinctive features that are worthy of notice.

Rising to a height of 78 ft. above ground level, the structure comprises an octagonal framed tower with three series of bracing members intermediate between the ground and the bottom of the reservoir, the latter having an external diameter of 26 ft., and a total depth of 18 ft. 6 in. from top to bottom. The reservoir comprises two compartments: (1) An inner tank of 20 ft. diameter with a conical bottom, the cylindrical part being 12 ft. deep and the conical part 5 ft. 6 in. deep; (2) an outer tank of annular form, 2 ft. in width between the concentric walls and 12 ft. in depth.



Sections of Gravesend Water Tower, Showing Inner and Outer Tanks.

This outer chamber serves the useful purpose of insulating the inner tank, and into it is led the supply pipe, of 12-in. bore, an inlet to the inner tank being provided at a height of about 3 ft. 6 in. above the bottom. The outlet pipe, 14-in. bore, from the inner tank is provided with a bell-mouth top, and projects through the conical bottom up to the cylindrical portion of the tank. Thus clarified water alone is drawn off, the conical portion serving the purpose of collecting sediment, which can be removed by means of a 10-in. bore wash-out pipe, a manhole with cast-iron cover, 24 in. by 18 in., being also provided. Near the top of the inner tank an overflow, 15 in. by 6 in., is formed in cement, discharging into a duct in the annular tank and fitted at the bottom with a 10-in. bore flanged cast-iron outlet, to which the overflow pipe is connected.

The water tower was designed by and constructed under the supervision of Mr. W. H. Salmon, in accordance with working details prepared by Messrs. L. G. Mouchel & Partners, Ltd., of Westminster. The contractors were G. E. Wallis & Sons, Ltd., of London and Maidstone.

Tunnel Construction on New Stevenage Line of Great Northern Railway (England)

From The Railway Engineer, London, November, 1920.

The Stevenage line, of which the first section from Enfield to Cuffley has been opened since 1909, was delayed in its construction by the war, but is now completed. The construction was divided into three sections, the first commencing by a junction with the existing Enfield branch line of the old Enfield terminus, and extending 5 miles to Cuffley. The second extended from Cuffley to Hertford, a distance of 6 miles 13.88 chains, and the third, from Hertford to the junction with the Great Northern main line at Langley, a length of 8 miles 35.31 chains.

On the second section of the railway—that from Cuffley to Hertford, are two viaducts, three underbridges, one overbridge, one subway, three foot-bridges, several large culverts and the tunnel under Ponsbourne Park which is the outstanding feature of this section. The tunnel is built entirely in the London clay and is 2,684 yd. in length, of which 2,420 yd. are straight and the remainder on 1-mile radius. The maximum internal width is 27 ft. and the height 25 ft. 6 in. from invert to soffit of arch, giving 20 ft. 9 in. from rail level; the walls and arch are 2 ft. 7½ in. thick and the invert 1 ft. 10½ in., the former being lined with brindled bricks. The brickwork is built in 4½-in. rings, except where 12 special solid brindled brick-bonders were arranged to pass completely through the tunnel ring, the first being placed at the junction of the invert with the side walls and the remainder spaced equidistant from each other to within 12 in. of the center of the tunnel, the opposite side being similar, a brick-arched drain 2 ft. wide by 2 ft. in height at center is provided on the invert of the tunnel, the two bottom courses having openings about every 18 in. to facilitate drainage and the space between this drain and the formation level was filled with suitable hard rubble. The excavation amounted to 92 cu. yd. and the brickwork to 26 cu. yd. per yard forward of driven tunnel.

Six working shafts with an internal diameter of 10 ft. were provided and of these five were made permanent. They are lined throughout with brindled bricks and vary in depth from 132 ft. to 60 ft. measured from the natural ground surface, which here reaches a maximum of 372 ft. above sea level, to rail level; the foundation rings in the crown of the tunnel are carefully bonded to form solid brindled brick eyes, the thickness of the brickwork at the bottom of the shafts being 2 ft. 7½ in., reduced in regular steps to 1 ft. 2 in. at ground level, then carried up 8 ft. in height above that level and surmounted by ashlar copings and wrought-iron gratings.

The tunnel portals call for no special description and it may suffice to say they are constructed in a plain solid manner. They were built in open cut, 4 yd. of tunnel being constructed with each face at the same time. The pilasters are battered and with the curved wing walls are of concrete faced with brindled bricks and finished with ashlar caps and copings.

The ordinary sized refuges are provided throughout the tunnel, 22 yd. apart on each side, the first being 11 yd. from the end on one side, whilst in addition larger refuges 10 ft. by 10 ft. by 10 ft. high in center are provided every quarter mile, these being sufficient to accommodate an average gang of track men and a certain amount of permanent way material.

Tunnel Building Methods.—The average length of driven tunnel dealt with at a time was 12 ft. 4 in. and it may be of interest here to generally describe the procedure and construction of one length. The work may roughly be divided into seven stages as follows:

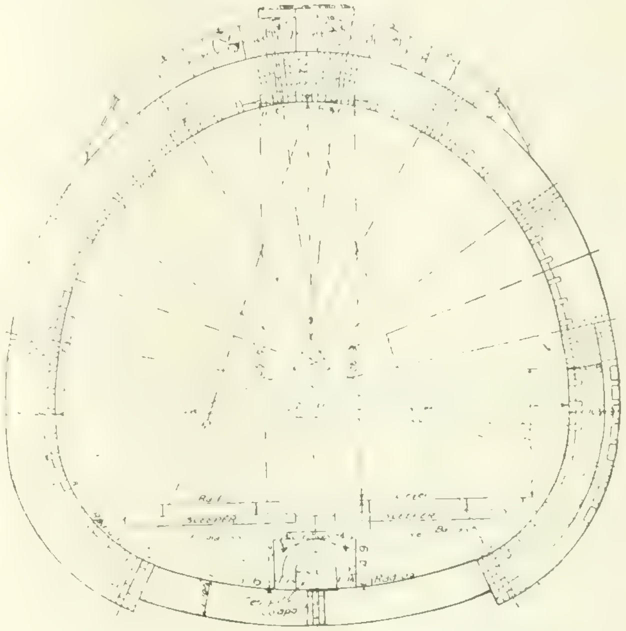
Stage 1.—The driving of a top heading, the insertion of head and side trees with footblocks. Drawing forward of second crown bars and propping them on stump back props.

Stage 2.—Widening the top heading and inserting the 4th, 6th, 8th, 10th and 12th taking-out bars and necessary poling boards all propped on top heading bed. A nipper sill was then fixed at the bottom of top heading on which to prop the crown bars.

Stage 3.—Long back props were then put in resting on footblocks down to top sill bed level, the 14th bar was inserted with further polings and the excavation cleared out to top sill level.

Stage 4.—The top sill and all props were then put in, excavation being carried on downwards and four back props to middle sill bed level inserted, these resting on footblocks. Two long raking props were then fixed from the top sill to a housing in invert of completed tunnel. Judkin rakers were then sometimes fixed, springing from the side walls of the preceding length laterally to the center of the top sill.

The excavation was then widened out and four more back props put in position on footblocks. The middle sill was then fixed and interprops placed between the top and middle sills and lining bars put in propped on to the middle sill with such additional poling boards as were necessary. Excavation was then carried down another stage with back propping as before to the bottom sill level, two short raking props being then fixed between the middle sill and the end of the finished tunnel invert and seven or eight props fixed between the middle and bottom sills, the back props above-mentioned raked back a little in order that the sills might be plumb with each other. The excavation was then finished and dressed out to profile ready for bricklaying. It may here be stated that the sills were usually 18-in. by 18-in. timbers, but varied with the nature of the ground met with. The long rakers were similarly 14-in. by 14-in. timbers, and timber drawing bars, including the 6th, 8th, 10th, 12th and 14th bars, from 12 in. to 15 in. in diameter and spaced about 18 in. apart, the Judkin rakers being used solely as a precaution.



HALF ORDINARY SECTION HALF SECTION THROUGH REFUGE

Sections of Ponsbourne Tunnel.

Stage 5.—The template for the invert was then carefully fixed and the invert bricked in.

Stage 6.—Side walls were built, both being carried up together and byots placed for construction of roof.

Stage 7.—The erecting of roof centering was then proceeded with. No. 4, 12-in. by 6-in. timbers were placed vertically and braced on each side of the tunnel and standing on brick projections previously built in the invert, these carried half-timber runners on which the byots rested; after the insertion of folding wedges between the byots and half-timbers, similar runners were placed on the tops of the byots which in turn carried four arch ribs constructed in seven segments, each out of 12-in. by 3-in. timber connected with iron straps and bolts. The leading rib was in duplicate and was marked out in brick courses on its edge. When these were adjusted, laggings were laid on as the work of bricklaying proceeded and was carried on until a space of about 2 ft. was left, then a rebated lagging was placed on each side of the center line and short cross laggings resting in the rebate were placed in position at right angles to the general lagging, and keying up was completed working transversely.

The excavation and timbering occupied about six days, the brickwork in invert and side walls about 28 hours, and the brickwork on the arch about 32 [illegible] about 8½ days for one complete length.

Any spaces between the tunnel ring and the excavated face was filled in with brick and grouted as the brickwork was carried up and the spaces between the drawing bars built in solid brickwork, the spaces vacated by the drawing bars being packed with bricks.

The number of drawing bars varied with the nature of the clay. In some cases six timber drawing bars were used, in others four, and again five were employed and latterly four steel drawing bars were used, each made up of two old steel rails bolted together which resulted in economy inasmuch as less material had to be excavated outside the extrados of the arch. These were built in at the junction length.

The use of explosives in small charges was allowed by the engineer within the tunnel profile, Polarite and Gelignite being the agents, but great care was exercised so that none of the disturbed material should be outside the tunnel ring.

Bottom headings, large enough to take low-sided wagons of standard gauge, were allowed between the south face and the nearest working face of shaft No. 1 and between the fifth shaft and the northern end, but only when the distance between the faces did not exceed 50 ft.

Unfortunately, the war broke out whilst this and other work on the contract was in progress and operations were slowed down so that the time occupied in completing the whole tunnel is no criterion of the actual time occupied in a unit length.

General 'Principles of Sewage Disposal in South Africa

By ALFRED E. SNAPE,

Professor of Civil Engineering in the University of Cape Town.
From The Surveyor, London, Oct. 29, 1920.

Efficient methods of sewage disposal are of comparatively recent adoption in South Africa. They have all been applied within the past 20 years, and even now there are many towns, mostly of small size, where there is nothing but the pail system of stercus removal.

General Considerations.—The problem is inseparably wrapped up with the provision of a sufficient water supply, and both are dependent upon economic conditions. South African municipalities have to face their own difficulties, which vary from those existing in the Mother Country. Their white population is small compared with English towns, and it is spread over a large area. Cape Town, the second largest town in the Union, has a total population of about 170,000, and of this a little more than half is white. But the area covered is very big; from one end of Cape Town to the other is a distance of 22 miles. Generally the white population and many of the colored population live in detached houses with a good deal of ground around them, the roads are wide, and there are many vacant plots between the built-on lands. All this means that the expense of sewering per capita, leaving out of account increased rates of wages and increased costs of materials, is greater relatively than in Great Britain.

Again, no sewerage system is of use without an adequate water supply. And the water problem is one which is dominant in all South African towns. There is hardly a town in the Union which is not at present constructing or taking active steps to construct new or additional waterworks. It must be remembered that the consumption of water per person in South Africa, a hot and dry country, is greater than here, and also that South Africa has practically no rainfall for six or more months in the year. This necessitates larger storage works than would be required for towns of similar size in Great Britain. And the problem is even worse in some parts of the Union, where droughts, with practically no rainfall to cause a run-off, have lasted for two or three years. It may be interesting to state that in most places in South Africa, after so many months of our dry and parching sun, a rainfall of 1 in. will give no run-off and only a succession of such rains or one of greater intensity will cause the reservoirs to begin to fill. Also, water is required for irrigation, [illegible] desire water for their gardens during the dry season.

A sufficient water supply is therefore a necessity before sewerage works can be contemplated. But efficient sewage disposal on the water-carriage system is recognized as the proper method from the standpoint of health and cleanliness, and much progress, particularly in the larger towns, has been made in this direction

This paper only attempts to deal with one problem—the efficient disposal of the sewage after it reaches the outfall works. Nor will it deal with those towns which discharge directly into the sea—the old city of Cape Town, Port Elizabeth and Durban, and, after tank treatment, the proposed new works for East London. It will touch on those works where artificial treatment is adopted—Wynberg, Bloemfontein, Johannesburg, Pretoria, Pietermaritzburg, Queenstown, and the Cape Town suburban works now approaching completion. Outside those mentioned there are no other municipal sewage disposal works in South Africa.

Differences from British Practice.—A general review of the different conditions pertaining in South Africa from those in Great Britain will first be given. In most South African towns particularly up country, the object of sewage disposal is to obtain no visible effluent, and to attain this without creating a nuisance. The reason of this is that in our warm climate for the greater part of the year our streams are dry courses, or contain only pools of water at intervals. Also, our Roman-Dutch law relating to the riparian rights of water is very stringent. The owner of a farm bordering a public stream has the right to withdraw water from that stream for domestic and irrigation purposes, and has the right to damages and an interdict if he can prove pollution of the stream above his property. No definition has been laid down in our courts of what is pollution, but from the summing-up of one of our most eminent judges, Sir John Kotze, and the verdict of the jury in a recent lawsuit against the Wynberg Municipality, the author can only draw the conclusion that water is polluted except it be a pure drinking water. The riparian owner is entitled to withdraw water for domestic purposes from a public stream; and, if he can prove that water not to that standard is being discharged into this stream above him, the law is with him.

Apparently, if the effluent fulfils standards such as laid down by the Mersey and Irwell Joint Board or by the Royal Commission on Sewage Disposal, this will not avail in defense, as English law is different and English conditions are different. This will not apply, of course, to places where the effluent is discharged into a stream where there are no lower riparian owners who are independent and who can claim damages, or who are so far away that under no circumstances could it be said that the water reaching them was polluted. South African designers have to bear this point seriously in mind.

Fortunately, we have our South African sun, and, with it, the ideal is no effluent and the works carried on with no smell which can cause a nuisance on contiguous property. For this purpose a large area of land is required for treatment, with buffer lands around the treatment area.

And this result has been attained. A visit to the Johannesburg sewage disposal works at Klipspruit, or to the Bloemfontein works near the Bloemspruit, will show that at both these places there is no visible effluent. The effluent is treated on cultivated land and there is no run-off.

Principles for Efficient Sewage Disposal.—The principles underlying efficient sewage disposal in South Africa are the same as those in Great Britain. We have followed closely the work done by British towns and by the Royal Commission, and we acknowledge our indebtedness. The author laid these principles down in a paper read at Cape Town in 1911 at a congress of the South African branch of the Royal Sanitary Institute, and he has seen no reason since to modify his general views.

There are three ways by which solid matter may be carried by liquids:

(a) In suspension; (b) in colloidal solution; (c) in crystalloidal solution. The author then summarised these principles as follows:

(1) The elimination of the suspended and colloidal solids from the sewage. These are termed sludge. How far to go in the elimination of colloidal matter will depend upon the character and amount of the land to be subsequently treated.

(2) The proper and hygienic disposal of the sludge.

(3) The oxidation of the remaining organic matter and ammonia in the liquid so as to be harmless.

These principles are generally accepted, and the extravagant claims made for the old septic tank and bacterial bed treatment are no longer recognized.

The author may be allowed to quote from a report which he made in conjunction with Mr. F. Walton Jameson, then town engineer of Pretoria, in August, 1919, to the Bloemfontein Corporation:

Conditions for Good Effluent.—"We may now state the general principles for the production of a good effluent. The sewage is first passed through a screen to remove the larger floating matter. Thence it is passed through a grit chamber for the purpose of depositing the heavier mineral matter. Afterwards it passes into sedimentation tanks, which are designed to bring down in the form of sludge as much of the solids in suspension as possible. These tanks differ in toto from septic tanks. Neither the sewage nor the sludge in them is allowed to become septic. The sewage issues from them fresh, and the sludge from them is emptied twice a day into septic tanks, where true septic action occurs. The process in the sedimentation tanks is simply a mechanical separation of the solids before septic action takes place. This fresh sewage is then ready for oxidation, which may be effected by oxidizing beds or by land. The difference between using an effluent from such a tank and one of a septic character on land is very marked. The latter absorbs oxygen on the land, thereby minimizing proper aëration of the roots of a crop and thus preventing proper growth. Except under special restrictive conditions, it is generally wrong in principle to waste any water which may be beneficially applied to land. There is no doubt that such an effluent has considerable value for the growth of crops.

"A particular point which has to be considered where the ground is of a colloidal character with little underdrainage is the minimizing of the colloidal matter from the tank effluent before it is applied to the beds or land. This must be taken into account in the design of the tanks.

Disposal of the Sludge.—"Coming back to the disposal of the sludge, which is brought into septic tanks, the sludge separates in two forms—scum and a heavier sediment at the bottom. The septic liquor is very foul, and is run off on to specially prepared land. In time the scum and heavy sediment meet, and then the tank is 'ripe.' It is closed down, and the sludge is dug out and removed to a suitable site to dry. Under our warm South African sun it becomes dry and friable and increased in 'fixed nitrogen' content. It has been found that such dry sludge, when ground to a fine powder and mixed with phosphates produced from bones and waste products from the abattoirs, forms a splendid fertilizer, which has a high economic value."

This has been written from the experience of the Pretoria works. A way has been found which is not expensive, and which gives a very satisfactory solution to our sewage problem. The author has given this rather long quotation as best expressing the general idea.

In the paper cited above, the author stated, with reference to the treatment of the effluent from properly designed sediment tanks:

"Here, again, we must not make a fetish of British methods which have grown up as a result of the shortage of land, the very large quantities of sewage to be dealt with, and the large amount of trades' waste with the domestic sewage. Most of these adverse circumstances to the use of land are absent in this country (South Africa). The Royal Commission on Sewage Disposal state that 'there can be no doubt that, where the soil is suitable and the area of land sufficient, the organic matters in sewage can be thoroughly oxidized by land treatment. This fact is well established not only by investigations made by earlier Commissions, but also by wide general experience.' The writer, having had experience of land irrigation, thoroughly concurs, and he also thinks that in South Africa, where water is scarce, it is a sanitary sin to waste effluent by not treating it on land."

Crops for Land Treatment.—There is a splendid crop which can generally be established under irrigation in South Africa —the South American alfalfa grass, or lucerne, as it is always called in South Africa. Its roots are deep, it grows quickly, and it forms most valuable fodder; it can be cropped about every six weeks. Wynberg, with a pure sandy soil brought into cultivation by tank effluent, grows lucerne which returns over £60 per acre per annum. Root crops, such as mangolds and swedes, do not flourish in South Africa. Teff grass, cattle-feeding melons, osier beds have also been found satisfactory. Cereal crops are not so useful, as they can only take a restricted amount.

South African Sewages Are Very Concentrated.—Another special problem which has to be remembered in laying down a sewage scheme is that South African sewages are more concentrated than those in Great Britain. All sewerage reticulation works there are on the separate system; they are modern, and admit very little ground water. In Johannesburg, particularly, the sewage is very strong. Only the center part of that town is sewered, and the night-soil and slops from the unsewered areas are discharged into "intakes" connected with the sewerage system. It must be remembered that water there is 5s 6d a thousand gallons.

The following figures taken from the medical officer's report show the comparison between Johannesburg sewage and that of Birmingham, which is considered a strong English sewage:

Town.	Total solids.	Dissolved solids.	Chlorine.	Total nitrogen.
Birmingham	196	129	20	7.7
Johannesburg	480	151	26	38

All in parts per 100,000.

This concentration means that great care is necessary in seeing that the tank treatment is suitable and efficient.

Method of Sludge Disposal.—The method of disposing of the sludge will be interesting, and that in use at Pretoria will be described. Twice daily the sludge is discharged into open septic tanks. After 24 hours' settlement there is the lighter sludge at the surface and the heavier sludge at the bottom. The intermediate layer of septic effluent is drawn off and treated on specially prepared land. These septic tanks are used in duplicate on alternate days; they are in use for twelve months and have twelve months' rest, when they are emptied and the sludge run for further drying on land. From chemical investigation it is found that this dry sludge contains about 3 per cent of fixed nitrogen. The smell during the drying and emptying is not appreciable and is entirely local. It will be noticed that the figure above for the fixed nitrogen is relatively high. This seems peculiar to South Africa, and no doubt to other warm countries, and must be the result of the action of the hot South African sun. The final report of the Nitrogen Products Committee on p. 312 states:

"The sludge contains the organic nitrogen compounds previously referred to, and when dried down to a moisture content of about 20 to 30 per cent may contain from 1 per cent to 2 per cent of combined nitrogen. This nitrogen, however, appears to be in a condition in which it is not readily assimilable by plants, and the resistant character of the nitrogen compounds is probably increased by the considerable amount of grease that is always present in domestic sewage."

This latter difficulty, from some years of practical experience, does not apply to the Pretoria method. It was argued that the sludge had a certain fertilizing value, but it was deficient in phosphoric oxide and potash. Dr. Juritz, the well-known South African chemist, gave this analysis of one sample: Nitrogen, 2.24 per cent; phosphoric oxide, 1.65 per cent; potash, 0.05 per cent.

What products would make up these deficiencies? At the Pretoria abattoirs there is a by-product plant which produces dried blood, meat and bone from the condemned carcasses. Analysis gave: Blood, 12.5 per cent of nitrogen; meat, 8 per cent nitrogen, 6 per cent phosphoric oxide; bone, 6 per cent nitrogen, 16 per cent phosphoric oxide. It was thus clear that, by mixing this dried blood, meat and bone in the correct proportions with the dried sludge, a very valuable fertilizer would be produced. This has been done successfully. When the drying of the sludge is complete, it is removed to a mill and ground into a fine powder. It is then mixed in equal proportions with dried blood, bone and meat, which has also been ground into a fine powder. The analysis of the resulting fertilizer is about 4¼ per cent nitrogen and about 9 per cent phosphoric oxide. The difficulty which then faced the Pretoria authorities was that this abattoir by-product was limited. The town engineer thought of all the dead animals—horses, dogs, cats, etc.—which he had been burying. A steam digester was erected and all these carcasses are put into it and the product is also mixed with the dried sludge. Thus, instead of being an expense, those dead animals are now of economic value.

Pretoria produces 350 tons of dried sludge per annum, which, after mixing, makes 700 tons of fertilizer. This readily sells at £10 a ton. It must be remembered that the South African meat export trade is rapidly expanding, and large abattoirs have been erected in all the big towns. Otherwise, in South Africa, the dried sludge is spread over lands which are cultivated

Description of South African Works.—Only a general survey of these works will be given.

Johannesburg.—The Johannesburg sewage farm at Klipspruit has a total area of 2,642 acres, of which about 1,000 acres are available for tank effluent disposal by gravity. There is a belt of land 600 ft. in width bordering and below the irrigable area, which is continually ploughed to prevent any possible overflow. This belt is not included in the 1,000 acres. Detritus and sedimentation tanks are installed; the latter are similar to the hydrolytic tanks constructed by the author when he was resident engineer under Mr. A. E. Collins, M. INST. C. E., city engineer of Norwich. The irrigable area is divided into five sections, so that tank effluent is applied to one section for a day, after which the land has four days' rest. The amount applied is between 9,000 and 10,000 gal. per acre in one day, and then there is four days' rest; the average is thus about 2,000 gal. per acre per day with continual application. About a mile below the farm is one of the deep pumping stations of the Rand Water Board. Continual analyses of the water pumped are made, but there has never been the slightest sign of pollution. As before mentioned, there is no visible effluent.

Pretoria.—Pretoria has a special problem for South Africa. It had only 26 acres of land available, of which 14 acres are needed for the treatment of the foul liquor from the septic tanks, already explained. Oxidizing beds were therefore necessary. Sewage enters a screening chamber and then flows into cone-shaped tanks which are similar to those designed by Dr. Watson, at Birmingham, on the Dortmund principle. From these the tank effluent passes through revolving sprinklers on to filter beds in efficient doses, each discharge representing 1.68 gallons per sq. yd. of filter. The material used in the beds is granite, and the average depth is 5 ft. 6 in. The effluent discharges into the Aapies river, and, as illustrating its value, the market gardeners below the town lead the water out of the stream again and find that it possesses most useful irrigating properties. This irrigable land fetches very high prices.

Bloemfontein.—The Bloemfontein scheme was designed in 1901, being one of the earliest South African works. It was on the principle of septic tanks, primary and secondary filter beds, after which the effluent was pumped and treated over land. Slight modifications have been made. There is no visible effluent.

Pretermaritzburg.—This town possesses sedimentation tanks modeled upon those at Birmingham, filter beds and land.

Cape Town.—The sewage from the city proper passes into the sea. New works are now being constructed to treat the sewage from the suburban area. There are double-story sedimentation tanks on the Imhoff principle. The effluent will then be oxidized in rectangular beds, which will be fed by a carrier moving backwards and forwards. The interesting feature about them is that the beds will contain closely packed bundles of brushwood, of which there is a considerable quantity in the vicinity.

Wynberg.—Wynberg is the municipality which has been involved in the lawsuit mentioned at the beginning of this paper. Complete new works on the Cape Flats have now been authorized and will be commenced immediately.

Queenstown.—The works at Queenstown consist of septic tanks, filter beds and land. They have proved that engine clinker, which was used in the beds, is unsatisfactory.

Conclusion.—In conclusion, the author may state that he has not gone into great detail; he has thought that it would be more acceptable to state general principles and to dwell on differences from British practice.

Essentially, the general solution of the sewage problem in South Africa is to produce an effluent without nuisance, which can be beneficially used upon and absorbed by land. As water is so valuable in South Africa, the author is of opinion that sewage effluent should be used for growing crops. A steady, even supply of water which can be used for irrigation raises the value of the irrigable land considerably. And although profits from a sewage farm as against efficient administration for its main purpose must not be considered, it is possible to obtain a good monetary return.

The experience at Pretoria does seem to imply that the sludge difficulty has been considerably minimized. The fertilizer produced—and South Africa is very much in need of fertilizers—seems to be satisfactory after being used for years.

Electrically Welded Steel Frame Building

From Engineering, London, Jan. 14, 1921.

Electric welding is now used to a fair extent in commercial vehicle building, etc., while its employment in connection with ship construction is well known. There is a further constructional field, however, in which electric welding would appear to offer many points of advantage and in which it is obtaining a sound footing. This is in replacing riveting for joining the various members together in steel building construction. Most of the joints which have to be employed in this class of work are types which lend themselves conveniently to welding methods. They are very straightforward and by employing a series of simple jigs it is possible to build up the various angles, strips, channels, etc., into roof principals, or other parts, very rapidly.

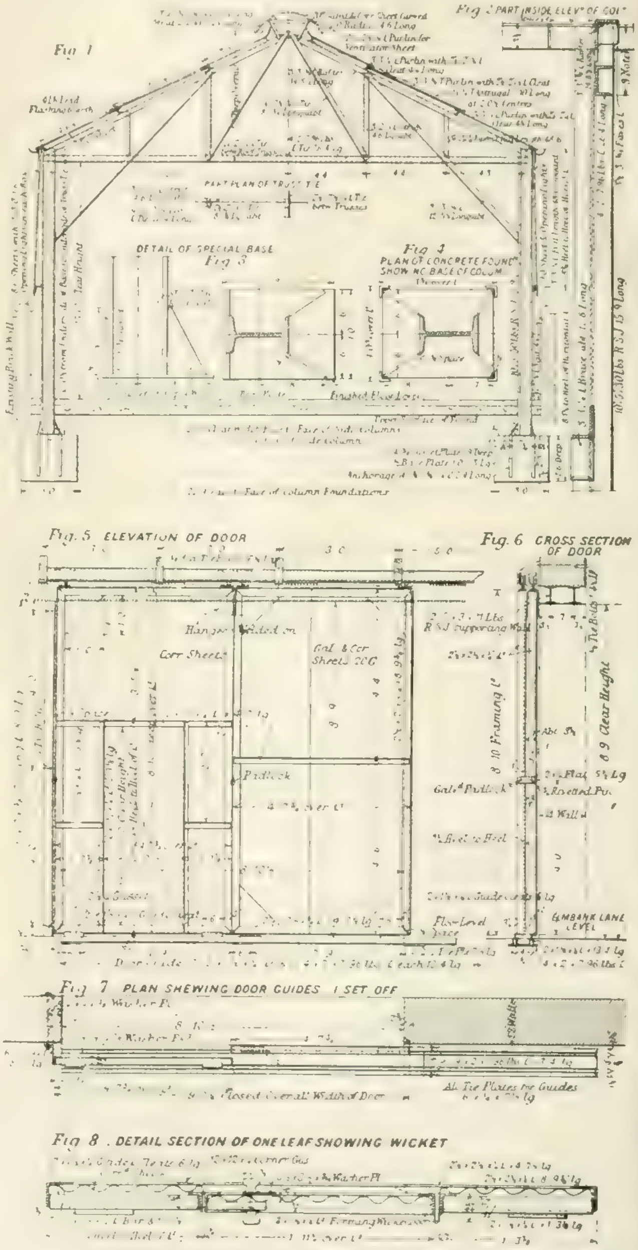


Fig 1
Fig 2 PART INSIDE ELEVN OF COL
PART PLAN OF TRUSS TIE
DETAIL OF SPECIAL BASE
Fig 3
Fig 4
PLAN OF CONCRETE FOUNDN SHEWING BASE OF COLUMN
Fig. 5 ELEVATION OF DOOR
Fig. 6 CROSS SECTION OF DOOR
Fig 7 PLAN SHEWING DOOR GUIDES 1 SET OFF
Fig 8. DETAIL SECTION OF ONE LEAF SHOWING WICKET
EMBANK LANE LEVEL

Fig. 1-8—Details of Electrically Welded Steel Frame Building.

One of the largest steel frame buildings which has been constructed by welding methods in Great Britain is illustrated. This constitutes the new workshops of The Double Arc Electric Welders, Limited, of 26 India street, Charing Cross, Glasgow. The steelwork throughout was welded by the company on their system. It should perhaps be said that the name of this firm is derived from the special flux with which they coat their welding electrodes. This flux is conducting, and it is claimed that an independent arc is formed between the flux and the work as well as the arc between the electrode and the work. This giv [illegible] arc. The building consists of a single bay of the cross-section shown in Fig. 1. It will be clear from this and from the other figures that the adoption of electrical welding has not necessitated any departure from recognized methods in the lay-out and general design of the structure. The welding was carried out by The Double Arc Electric Welders themselves. The building was designed by William Bain & Co., Limited, of Coatbridge.

The building is 27 ft. wide by 50 ft. long and the ends are closed by brick walls forming parts of other structures which were in existence when it was erected. At the sides there are boundary walls about 5 ft. high, which were in exist[illegible] when the building was erected. These carry copings, as can be seen in Fig. 1, and they have been connected up by galvanized flashing to the corrugated sheets which close the sides of the building. There are five roof principals of the type shown in Fig. 1. They are spaced 11 ft. 6 in. apart and are carried on columns, which consist of 10-in. by 5-in. joists with welded-on bases. As shown in Figs. 1 and 4, the base of each column sits on a rectangular ½-in. plate, to which it is welded. Gusset plates, ⅜ in. thick, are then welded between the outer edges of the flanges of the joists and the baseplate. As will be clear, this makes an easily assembled and stiff construction. The baseplate is anchored to the foundation block by four 1¾-in. by 1¾-in. angles set vertically in the block, the arrangement being indicated in Figs. 1 and 4. A special form of base employed where space was restricted is shown in Fig. 3. A single gusset plate, 12 in. by 9 in., in this case replaces two of the gussets in the standard construction. The arrangement will be clear from the figure.

The roof principals are built up of two 3-in. by 3-in. by ⅜-in. angles, forming the main rafters, which are connected at the bottom by a 4-in. by 2-in. channel. These two members are welded to the webs of the columns, as can be seen in Fig. 2. Angle struts, 3 in. by 2 in. and 2 in. by 2 in., connect the horizontal member with the rafters. They sit on and are welded to the top flange of the horizontal channel. The diagonal ties are of 3-in. by 3-in. and 2½-in. by 2½-in. angle Their connections to the columns, rafters and horizontal tie will be seen in the figures. The main trusses are tied together by a 2½-in. by 2½-in. angle welded to the top flange of the main horizontal members. The roof is of corrugated galvanized sheets, with a row of lights along the center of each slope. All purlins are of 3-in. by 3-in. angle welded to the rafters. Angle brackets are in turn welded to the purlins to carry the sheets or the frames of the glass lights. The arrangements for securing the curved ventilator sheet which forms the ridge of the roof are shown in Fig. 1.

Access is obtained to the building by a sliding door at one end. This also is built up entirely by electric welding and forms an interesting example of the type of work which may readily be carried out on the system. It is illustrated in Figs. 5 to 8. As will be seen, the door consists of two leaves, each built up on a frame consisting of 2½-in. by 2½-in. by ¼-in. angles, with gussets welded at each corner. The right-hand leaf is stiffened with a 2-in. by 1½-in. angle across the center of the panel, one flange of which is welded flat against the flanges of the uprights at each end. The left-handed leaf is furnished with a wicket gate and a simple framework is built up inside the main panel to carry it. The arrangement is clearly shown in Fig. 5. The method of carrying the sliding door does not differ from ordinary practice. It is illustrated in Figs. 5 to 7. A horizontal cross-section through the left-hand leaf of the sliding door is given in Fig. 8. This shows the arrangement of the wicket and indicates that the welding system lends itself to a neat and workmanlike arrangement. The frame of the wicket gate itself is built up of 2-in. by 1½-in. by ¼-in. angles. The joints are butt-welded at the corners and no gusset plates are used.

Subways for Tokio, Japan.—Plans for 30 miles of subway lines to be built in Tokio, capital city of Japan, are now under consideration, according to a press dispatch. The Tokio Underground Railways Co., Ltd., has recently voted to increase its capital stock from $5,000,000 to $40,000,000. If the plans as submitted are carried out Tokio will have the first underground railway line ever built in the Orient. While the company's plans are still in the formation stage, it has gone as far as to establish headquarters in the Kaijo building, Tokio.

Strengthening and Reconstruction of Railway Bridges

From The Times Engineering Supplement, London, February, 1920.

Of two papers dealing with the strengthening and reconstruction of railway bridges, read before the Institution of Civil Engineers, one, by Mr. George Ellson, described the work carried out at the Cannon St. bridge of the South-Eastern & Chatham Railway, and the other, by Mr. F. W. A. Handman, the method adopted in the case of a viaduct on the Sul Espirito Santo line of the Leopoldina Railway in Brazil.

South-Eastern & Chatham Ry. Bridge.—When the Cannon St. bridge was built by Sir John Hawkshaw in 1865-66 the heaviest engine employed weighed 52¾ tons, and had a length over buffers of just under 48 ft., so that the weight per lineal foot was 1.1 ton. That weight has since become 1.9 ton, and is regularly increasing, and if the girders had been loaded to the maximum the stress in some of them would have amounted to about 8 tons per square inch. Restrictions had, therefore, to be imposed on the traffic working over the bridge, and it was to enable these to be removed that strengthening was decided upon.

The superstructure, which is supported by four piers of cast-iron columns, consists of free span plate girders, each 130 ft. long, over the two shore openings, and continuous plate girders 442½ ft. long over the three middle spans, which are each 147½ ft. The plan adopted was to build new sill girders at the piers and additional girders in between the existing girders, the old and new girders being connected by rows of diaphragms. The six new, continuous girders, each weighing about 187½ tons and 443 ft. long, were threaded into position between the existing girders from the south end of the bridge. The old main girders were only 5 ft. between centers and their booms were 2 ft. 2 in. wide, so that there was only a width of 2 ft. 10 in. in which the new girders, also 2 ft. 2 in. wide, could be fixed; and as the latter had to be placed at the same level as the old girders the space in which the necessary riveting had to be done was very restricted. The sections of girder work, each about 40 ft. long, and weighing from 10 to 18 tons, were delivered by barge and built up on a staging erected in the river under the south span. As section by section was riveted to the preceding length the forward end of the girder was launched out over the waterway in the Surrey intermediate span, and as soon as the completed length of the girder permitted, a bearing was taken on a rolling apparatus on a staging at the south side of the Surrey intermediate span. When the girder projected 70 ft. in the clear over the rollers a launching-prow 25 ft. long was fixed to its front end, to preserve the balance, thus completing its span over to the landing stage at the northern end of the Surrey intermediate span. The launching of the girder was then continued on rollers until a length of 262 ft. had been built up; this was then moved northwards until it reached its final position, the launching-prow being removed when the staging erected in the Middlesex intermediate span was reached. The remaining length of 181 ft. was built up and launched forward in the same way, until its front end abutted on the back end of the first length, when the junction was riveted, with due precautions to ensure the proper continuity of the girder without initial stress.

Before the strengthening the deflection in the middle span of the continuous girder was ⅜ in., and in the other two spans ½ in. under ordinary traffic conditions; but after it six of the heaviest engines, coupled together and giving a total live load of 525 tons, caused a total deflection of 5/16 in. in the middle span and ¼ in. in the side ones. The distributing action of the diaphragms caused the adjacent girders at the same time to deflect ⅛ in.

Espirito Santo Viaduct.—The Sul Espirito Santo viaduct consisted of a continuous 197 ft. steel lattice deck span supported on two steel trestles 68 ft. 8 in. between centers. When it was desired to increase the live load on the line, both the trestles and the girders were found to be inadequate for the stresses to be resisted. The problem was therefore to reconstruct the trestles and replace the continuous span by three whole plate deck spans weighing 38 tons each, without interrupting the passenger traffic, the interval between trains being 24 hours.

The trestles were encased in concrete, this method avoiding falsework and interruption of the traffic on the girders presented greater difficulties. Having been riveted up at a siding 3 km away (there was no space for a temporary siding at the site), each complete span was run into position over the old span on two 20-ton bogie trucks and by means of wooden cribs and four 50-ton ship's hydraulic jacks were lowered to rail level. The end sway braces and laterals of the old girder were then cut away by oxy-acetylene, and the new girder was supported by cribs directly on the abutments or piers. The continuous girder was next cut completely through over the pier, the two sections slid outwards on special guides, and the new girder lowered into place. In the case of the first girder the track was prepared for the train and the work completed with 30 minutes to spare. The other two girders were placed in position in a similar manner on subsequent days, without hitch.

Work of the Quantity Surveyor

By F. H. A. HARDCASTLE.

From The Surveyor, London, Dec. 24, 1920

Bills of quantities are the result of the natural desire of men proposing to build to be informed beforehand of the probable cost of their enterprise.

The Surveyor's Liability.—The somewhat casual manner in which the profession has grown up has led to uncertainty touching the nature and extent of the surveyor's liability. The recognized rule of law is that any man undertaking and receiving pay for professional work must bring reasonable skill and care to the discharge of his duties, failing which he is guilty of negligence and liable to be mulcted in damages for any loss thus caused to the person who has employed him.

The uncertainty as to the surveyor's liability to the builder arose from the circumstance that only in form did the builder pay the surveyor, the cost being in reality borne by the building owner, and in the case of Priestly and Gurney vs. Stone it was held that there existed no "privity of contract" between the builder and the surveyor, and therefore no legal liability on the part of the surveyor to the builder. The effect of this judgment appeared to be that in the large class of cases in question the surveyor was under no liability to anyone; a manifestly unsound position, unjust to the public, and derogatory to the profession. Contractors naturally took alarm, and action was taken by builders' associations. An attempt was made in the first instance to go to the other extreme and call upon the surveyor to be responsible for the literal accuracy of his work, a liability such as assumed by no other professional man in the kingdom. After some discussion this position was given up, and in the end it was arranged that the surveyor should undertake to be responsible to the builders tendering on his quantities in the same manner as if direcly employed by them, which brought the surveyor at once under the common law touching negligence.

The imputation that surveyors tried to evade all liability for bad work was naturally galling to men of spirit, and an attempt was made in one quarter to meet it by establishing a voluntary professional court to hear and adjudicate on charges of negligence by quantity surveyors and award damages and costs. I do not know to what extent recourse has been had to this tribunal by building owners and contractors.

Quantities as Part of Contract.—A question a good deal discussed formerly—not so much of late—is whether, the surveyor being appointed by the employer or by his architect, the quantities should form part of the contract. The great preponderance of opinion is in favor of that course, and to my mind its equity is incontestable. What in practice usually happens? The builder has no voice whatever in the choice of the surveyor. Indeed, until he receives the bills he commonly does not know who the surveyor is. He is supplied at the instance of the employer, or his agent, the architect with a document which purports to be a detailed measurement of the work proposed to be done, the accuracy of which he has no adequate means of testing, and which at the same time is, and indeed must be, the basis of his calculations.

In addition, he is usually required to hand over a copy of the bills fully priced for the purpose of adjusting variations. To say, after all this, that the bills of quantities are no concern of the building owner is manifestly inequitable. Great pains have, however, been taken by building owners to avoid or evade all responsibility in this respect. A well-known public authority, for many years after they had adopted the practice of themselves appointing the surveyor, always notified him that he was "permitted" by the board to prepare the quantities for such and such a building, and in the contract the following clause appeared:

> The quantities which have been taken out by (Messrs. A and B) with the concurrence of the board and the contractor shall not in any respect form part of this contract, and neither the board nor the contractor shall be in any respect bound thereby, or be answerable for the correctness thereof, although the said (Messrs. A and B) may have been nominated and paid by the board, any agreement between the architect and the contractor and any custom of the trade to the contrary notwithstanding.

In the advertisement inviting tenders, moreover, the tantalizing announcement was made that builders tendering were to examine the bills of quantities and satisfy themselves of their accuracy. I need hardly say that all this is now a thing of the past. The simple and rational course is to make the quantities part of the contract, and the surveyor, like the architect, an agent of the building owner, who is then liable to the contractor for the acts of the surveyor as he is for the acts of the architect, and both professional men are responsible to the building owner, their employer.

Quantity Surveyor and Architect.—Ought the two professions of quantity surveyor and architect to be kept separate or united in the same person? I am naturally biased, but to my mind the mental qualities proper to the two callings are so distinct, even diverse, that I should as soon expect an accomplished architect to be a good quantity surveyor as to expect a poet to be a senior wrangler. There is also a clear advantage in the bill of quantities being the expression of the independent and unbiased opinion of a man who devotes his whole time to that work, and whose reputation is bound up with it.

Uses of Quantities.—The primary use of quantities is the obtaining, in a reasonable time, of competitive tenders on an identical basis. A secondary, though important one, is the furnishing of an extensive and convenient schedule for valuing variations. In most cases the surveyor who has prepared the quantities adjusts the variations. Some discussion has taken place touching the manner in which this work should be done. I think it is generally done with fairness, but there is no doubt a possibility of abuse. I remember a case in which an educational authority by acquiring during the progress of the contract an adjacent piece of land was able to increase the size of the playground. The surveyor, in adjusting the variations, omitted all the work in connection with the playground as it appeared in the original estimate, and then measured the whole enlarged playground as executed. He need only have measured the new piece. That was no doubt an extreme and exceptional case. It is suggested, as a rule, that if an item is altered only in one dimension or in description, the difference only should be measured; if altered in more than one dimension, the item should be measured.

While surveyors are no doubt sometimes open to criticism, I think that they often get less than justice in this matter. It is forgotten that a surveyor will frequently spend much time in measuring whitewashing, painting or inexpensive fittings, and the like, his commission on which will not pay him assistant's wages; often also he will occupy many hours in arguing in opposition to claims which are ultimately withdrawn.

Another signal use of quantities is the regularizing of work which is rendered possible by subjecting it to the analysis involved in bringing it into a measured bill. It is there reduced to ordinary terms of labor and material, and can be conveniently compared with other work.

Quantities are also useful in the preparation of detail drawings. In most cases architects do not prepare all their details before the contract is signed. No set of drawings, and no specification ever yet did, or could, deal with every point, and much information is usually to be found in the dimensions of the surveyor, who, with his mind following every process of every trade, has necessarily dealt with the whole of the work in detail.

Another useful function of quantities is in making valuations for payments on account. No other means can compare for a moment with the use of the priced estimate for this purpose.

Misuse of Quantities.—An instance of the abuse, or misuse, of quantities is when an architect—alarmed at the growing cost of the building—searches the deposited bills and orders the omission of work to which a high price is attached so as to reduce his expenditure. This abuse has been met by the priced bills being deposited sealed up and not opened till towards the end of the contract. When this is done they should be first examined by the surveyor. I have known a sealed-up set of bills which, when opened, turned out to be blank. Apart from all this, there is the disadvantage that sealed-up bills cannot be used for valuations for interim certificates.

The Proposed Standard of Measurement.—The proposal of a standard method of measurement has, I am aware, been the subject of sharp controversy, and I readily admit that a good deal may be said on both sides. But the preponderating weight of argument is, in my judgment, in favor of it. We all know that quantities are often issued which entirely fail to give the information they purport to convey, and reflect little credit on those who have produced them. A builder's estimating clerk once showed me the bill of quantities for a mansion to cost about £35,000 (pre-war). One item in the joiner's bill was for a wainscot oak staircase, 4 ft. 6 in. wide and going up two stories. It was given as "No. 1 staircase," followed by about a page of description of the treads, the handrail, balusters, and newels, etc., evidently copied from the specification, and ending with the well-known and useful word "complete." The dormers were also numbered, including casements and frames, glass, ironmongery, lead tops and cheeks, trimming rafters, plastering, etc., also "complete." In this case the quantities were taken out, or, at any rate, signed by the architect, and the surveyor's commission charged was 2½ per cent. Usually, I venture to think, an architect would not allow an independent surveyor working under him to palm off such work as this. When the architect prepares his own quantities, however, there is no one to impose a check. The movement, now very noticeable, to extend this practice among architects, itself supplies an additional reason for a standard method.

The glowing tendency in the direction of sub-contracting is here very much to the point. It is now not unusual to sublet slating and tiling, steelwork, plastering, glazing, and, to a less extent, plumbing. The result is that each of these trades fight vigorously for its own hand, and brings a constant pressure to bear in the direction of fresh sub-divisions and fresh labors, all in the interest, or supposed interest, of the particular trade.

Catenary Measurements

From The Times Engineering Supplement, London, February, 1921.

The catenary curve formed by a chain or flexible hawser of uniform section and material, loaded only with its own distributed weight, enters into innumerable problems that arise among engineers, physicists, and sailors. It is frequently possible to arrive at approximate solutions by assuming the curve to be a parabola, or by adopting an empirical formula. By mathematicians the properties of the curve can be easily expressed in terms of hyperbolic functions and a modulus. The engineer and the physicist, however, require arithmetical solutions and simple methods of obtaining accurate results, and they are frequently unable to assign a value to the modulus.

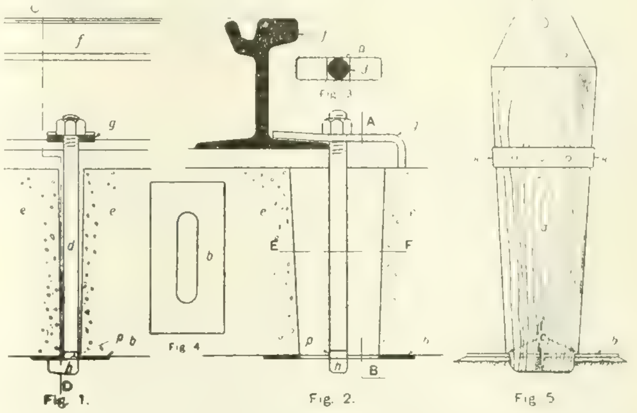
In the Proceedings of the Institution of Civil Engineers, Vol. CCVIII, Part II, Mr. Rollo Appleyard describes a new method of dealing with problems of this kind. The primary requirement is to discover the true arithmetical relationship between the lengths of the bight, span, and dip of any given catenary. The next step is to calculate arithmetically the stress at any point in the curve. It is then useful to be able to calculate easily the slope at the ends or at any point, and to draw the curve. Mr. Appleyard finds that there is a fundamental relationship, which he calls "the catenary length-function." This function is in itself somewhat complex, but he has calculated it for all values, and has tabulated the results as a series of numbers, so that the arithmetic of catenary problems is now reduced to very easy operations. By the aid of this table of length-functions, the relationship between bight, span, dip, slope, and tension, can be accurately determined. It is remarkable and very instructive to observe how simple the equations become, and how they merge into one another, when the "length function" is introduced.

Device for Fastening Rails to Reinforced Concrete Slab Foundation

From The Engineer, London, Feb. 4, 1921.

A simple but effective method of securing flat-bottomed rails to reinforced concrete slab foundation is shown in the accompanying illustrations. Figure 1 is a section on the line A B of Fig. 2 and shows a tramway rail f in elevation; Fig. 2 is a cross section through the rail f on the line C D of Fig. 1; and Fig. 3 is a cross section through the slab in the concrete raft e on line E F of Fig. 2.

The procedure employed in using the device is as follows: After the formation has been leveled off and the interlocked double-layer reinforcement laid in position, the foreman attaches to the top layer of steelwork the marking out lines, giving approximately the positions of the rails at desired spacings. On these lines he fixes vertically on the formation and transversely to the rails tapered wooden templates a, as shown in Fig. 5, each of which is fitted at the rabbeted lower end c with a loose thin slotted base plate b of thin stamped-out metal, shown in Fig. 4. Through a hole w in the top of each template is passed a rod or bar connecting three or more templates together. The top of the horizontal bar is levelled off to rail level by packing up under the base plate b with sand. After all the templates are thus set up the concrete is put in position up to the lower edge of the iron bank k on the template, the top edge of the band being identical in level with the underside of the rail f in Figs. 1 and 2. After the concrete is partly set, the templates are slightly eased and subsequently removed completely when the concrete has set hard. Their removal results in the leaving in the concrete e of slotted holes, which are surrounded at the bottom of the raft by the flat, slotted base plates b.



Device for Holding Down Rails to Concrete Foundations.

When the concrete is sufficiently set, the rails are laid in position on its surface at the required level, being packed up on small pre-moulded concrete wedges or other suitable packing. Into the tapered holes in the concrete are then dropped headed bolts d, which have, close up against their head, a short length of square neck p. The bolt head is pushed down into the cavity which is left below the base plate by the removal of the projecting lower end of the template, until the square neck is below the base plate. The bolt is then turned through an angle of 90° and pulled up until the square neck fits in the slot of the base plate, and so prevents the bolt from being turned round when the nut is being tightened. For convenience in fixing the bolt is supplied by the makers with a notch cut in the top of the reserved end, which notch indicates the position of the shaped head of the bolt. The bolt can be used to secure the rail either by being passed through a hole drilled in the base of the rail, or as shown in Figs. 1 and 2, by means of a bent clip g.

After the nuts have been screwed down and the slotted holes in the concrete filled with sand to within ½ in. of the concrete surface the concreting is resumed and care is taken thoroughly to pack and grout the concrete under the rail, so as to prevent any subsequent "pumping" action, which is so common with the rails badly bedded and fastened down.

It is claimed that no particularly careful setting out is required in fixing the templates, [illegible] in. or 6 in. length which is given to the slot in the concrete affords ample margin for any slight error on the part of the trackman. It is claimed, furthermore, that the adjustment to rail level of the rod passing through the holes in top of each template automatically ensures: (a) Correctness in the level of the surface of concrete e; (b) ample uniformly regulated space for packing and grouting under the rail and (c) uniform length of bolts. It is also pointed out that in the case of renewals due to settlements, wear, or otherwise, it is a simple matter to take out and renew the bolts and to attach the rail again securely without having to place imperfect reliance on green, immature concrete or grout in lewis holes, or the like.

The system, which, we understand, has been found applicable to other usen in securing structural members other than rails to either plain mass concrete or to concrete rafts, is the invention of Mr. J. H. Walker, and the Walker-Weston Co., Ltd., of 7, Wormwood, E. C. 2, London, has undertaken the commercial development of the system in all its applications.

Results of Large Scale Operation of Activated Sludge Process at Manchester, England

By EDWARD ARDERN,

From the Journal of the Society of Chemical Industry, London.

In view of the satisfactory results obtained from the experimental investigation of the activated sludge process as applied the treatment of the sewage received at the Withington sewage works, Chorlton-cum-Hardy, of the Manchester Corporation, which were described in 1916, a large-scale continuous flow demonstration plant, designed to treat 250,000 gal. of sewage per day, was installed at these works in October, 1917, with the view of studying the process under working conditions.

In the present communication it is proposed to give a description of this installation, together with a general account of the results obtained during the two years it has been in operation.

The earlier investigations were practically confined to the operation of the process on the "fill and draw" system, in which both the aeration of the sewage and settlement of the sludge were effected in the same vessel. There are several objections to this intermittent method of operation, chief of which are the fall required for the discharge of the clarified effluent and the constant attention involved.

In translating the process to the working scale, therefore, the plant was so designed as to allow of its continuous operation, which not only obviates the above-mentioned disadvantages, but at the same time renders the process more adaptable to the treatment of the fluctuating flows of sewage received at the disposal works.

The plant, which was designed by Jones & Attwood, Ltd., Stourbridge, in consultation with the author, occupies one-third the area of one of the existing sedimentation tanks, and may be described as follows:

Aeration Chamber.—The aeration chamber, 100 ft. long by 22 ft. wide (over all) and 6 ft. deep (water level to diffuser), is divided by four longitudinal walls so as to form a channel 4 ft. wide and 500 ft. in length. Its capacity is 55,000 gal. The floor of the channel is constructed on the ridge-and-furrow system, the ridge having a slope of 35° with the horizontal. Aeration is effected through rows of diffusers laced in the furrows transversely to the flow of sewage. The diffusers are each 1 ft. square over all, so that their total area is approximately one-seventh of the aeration tank area. The ratio of the net diffusion area to total tank area is 1:10. An overhead system of air pipes is provided, and the air is admitted to the diffusers through a series of down pipes, arranged so that one pipe serves two diffusers. Valves are attached to the various distributing pipes, so that the air supply may be regulated and distributed uniformly.

Settlement Tank.—Separation of the activated sludge from the purified effluent is effected in a deep pyramidal tank, 23 ft. 6 in. by 26 ft. 6 in. in plan, and 23 ft. 6 in. deep from water level to apex of tank. The sides of the tanks have a slope of 60° to the horizontal.

The mixture of effluent and sludge is admitted to the center of the tank through a 15-in. pipe within a guard chamber 6 ft. square, and discharges into a deep wrought-iron bucket suspended from the top of the pipe. This arrangement was designed by Mr. W. Clifford with the view of dissipating the energy of the incoming flow by the creation of eddies within the guard chamber, and thus to produce, as far as possible, a quiescent condition at the bottom of the guard chamber, and so allow the efficient settlement of the sludge. The final effluent leaves the tank over four corner peripheral sills. The total capacity of the settlement tank is 27,000 gal.

Sludge Circulation.—The sludge is discharged by hydrostatic head from the apex of the tank through a 6-in. pipe to separate chamber fitted with diffusers, from which it is returned by air-lift to the aeration chamber.

Surplus sludge is either pumped from the return sludge chamber onto drainage beds, or is removed by syphon to the existing sludge well and discharged mixed with the sludge from the sedimentation tanks onto the land.

For the air supply, a belt-driven Reavell compressor, designed to deliver 500 cu. ft. per minute at anything up to 15-lb. pressure is employed. The machine is driven by a disused tandem high-pressure air compressor, which has been converted into a steam engine by removal of the air piston and the provision of a new driving pulley.

A Lea flow recorder has been installed at the exit end of the plant, and the purified effluent is measured as it passes over one or more V notches. Four such weirs are provided so as to obtain an accurate record of considerable variations in actual flow.

The air consumption is measured by calculations from piston displacement and engine speed.

The sewage prior to treatment in this plant is screened and flows through two detritus tanks, the combined capacity of which allows of 40 minutes' detention in normal dry weather.

When the plant was first brought into commission a flow of sewage was passed through at the rate of 100,000 gal. per day for 15 hours out of the 24 (6 a. m. to 9 p. m.). During the rest of the day the flow was shut down and the contents of the installation circulated by means of the air-lift placed in the sludge pit connected with the settlement tank. In this way satisfactorily purified effluents were obtained during the period required for the production of an active sludge.

As the amount of sludge increased the volume of sewage treated was gradually raised without interfering with the degree of purification effected.

When this sludge present in the aeration chamber had increased to 20 per cent by volume, measured after one hour's settlement, the flow of sewage was stopped and the contents of the plant circulated as previously described until the liquor was free from ammonia. At this stage the activity of the sludge was such that the installation was capable of treating 100,000 gal. of sewage per day with practically complete nitrification. During the next few days the flow of sewage was gradually increased from 100,000 gal. to 250,000 gal. per day, with the maintenance of a high degree of nitrification. In this manner an adequate supply of activated sludge was produced in rather less than a month, to enable the plant to be brought into full and regular commission.

Average Results Over Various Periods.—A series of overage results over various periods, which demonstrate the

[illegible] RESULTS IN PARTS PER 100,000.

	Dry weather sewage.				Wet weather sewage.			
	Maximum air supply.*		Low air supply.‡		Low air supply.*			
	Sewage.†	Effluent.	Sewage.†	Effluent.	Sewage.†	Effluent.	Sewage.†	Effluent.
[illegible] absorption	3.53	0.66	3.90	0.73	2.53	0.67	2.93	0.60
[illegible]	3.00	1.53	2.66	2.31	1.94	1.63	2.11	1.54
[illegible]	0.59	0.10	0.66	0.115	0.46	0.13	0.53	0.11
[illegible] NH₃	....	0.64	....	0.14	....	0.37	....	0.34
[illegible] absorption (Royal Commission test)	..	0.93	....	0.93	....	1.00	....	1.34
[illegible]	18.0	3.0	....	....	13.0	3.4	....	....
[illegible] gallons per day	250,000		250,000		340,000		500,000	
[illegible] air per gallon [illegible]	1.7		1.0		0.8		0.9	

[illegible] †Screened and [illegible]-feed sewage. ‡Flow roughly proportional to rate sewage is received.

capacity of the plant under varying conditions [illegible] in Table I.

The volume of sludge employed in the aeration chamber has varied from 15 to 30 per cent, measured by volume after one hour's settlement.

The figures for air consumption include the volume required for working the air-lift, returning the sludge from the settlement tank to the aeration chamber, which amounted on the average to about 10 per cent of the total volume employed. The volume of thin sludge circulated by the air-lifts varied from 110,000 gal. to 250,000 gal. per day (average 150,000).

It will be seen that the effective capacity of the plant is well above the 250,000 gal. per day for which it was designed.

The figures given for the results obtained when treating the sewage at the rate of 500,000 gal. per day cover a period of eight weeks, continuous operation at this rate. Towards the end of this period the sludge showed signs of diminished activity, which necessitated a return to a lower rate of flow. It is, however, evident that the plant is capable of operation at this high rate for limited periods when the sewage is diluted by appreciable rainfall without interfering with its efficiency.

The chief characteristics of the effluents obtained are their remarkable clarity, the ease with which they pass the Royal Commission suggested standard of 2.0 parts dissolved oxygen absorbed per 100,000 after incubation with aerated water for five days at 65° F., and their low bacterial content, which averages about 20,000 organisms per c.c. (G. P. B.), which represents a reduction of 98 per cent on that of the sewage treated

Sludge Production.—Special attention has been paid to the amount of sludge produced in the process. Two typical determinations are given below:

SLUDGE PRODUCTION.

	1919	
	Sept. 18 to 30.	Oct. 1 to 31.
Volume of sewage treated (gal.)	3,360,000	6,310,000
Volume of surplus sludge (gal.) per million gal. sewage treated	23,200	35,300
Water content of sludge	99.4%	99.6%
Dry solids (lb. per 1,000,000 gal. sewage flow)	1,342	1,348

The above volumes of sludge are the quantities actually removed from the plant (during the respective periods) by syphon from the sludge chamber, connected with the settlement tanks, during the operation of the plant.

Sludge of increased density and consequently reduced volume could be obtained if the operation of the plant was interrupted during sludge removal. Where actual volume of sludge is a deciding factor in respect of its disposal, ancillary settlement tanks should be provided whereby a reduction in volume can readily be effected. These two periods are given as illustrating the great variation of the density of the sludge in circulation, and this question of sludge volume will be referred to later.

In connection with this important question of sludge production the following information is of interest in regard to the respective suspended solid content of the screened and detritus-freed sewage treated and of the effluent yielded:

Suspended solids.	Sept. 18 to Oct. 31, 1919.		
	Average total.	Mineral matter.	Organic and volatile matter.
Parts per 100,000 (excluding colloids)—			
Sewage	12.7	3.5	9.2
Effluent	1.1	0.4	0.7
Difference	11.6	3.1	8.5
Equivalent to lb. per 1,000,000 gal.	1,160	310	850
Dry matter calculated from sludge production	1,346	306	1,040

Judging from these results, the sludge produced (dry matter) is greater than is accounted for by the difference between the suspended solids contained in the sewage treated and in that passing away in the effluent.

It would thus appear that any resolution of the sludge by carbonaceous fermentation is considerably more than counterbalanced by the solid matter resulting from the flocculation of colloidal soils and the growths of numerous higher organisms.

Attention should be called, however, to the difficulty of obtaining over a long period a true sample of such a heterogeneous mixture as sewage, and it is possible that some of the grosser suspended matters escape sampling.

Characteristics of the Sludge.—The sludge as it is withdrawn from the plant is dark greyish-brown in color, and possesses a not unpleasant earthly odor, something like that of exposed seaweed. It is quite flocculent, and has the appearance of an iron or alumina precipitate. Its density varies very considerably, but it may be reduced to a fairly constant water content of 98.5 per cent by settlement alone. When the percentage of water is reduced to 90 per cent by treatment on drainage beds, centrifugal action, or pressure, the sludge is no longer fluid, but is of the consistency of a fairly stiff jelly, due to its gelatinous nature.

Mention has been made on a previous occasion of the high bacterial content of this sludge, which varies from 10,000,000 to 30,000,000 organisms (G.P.B.) per c.c. A special study has been made of the great variety of protozoa present in the sludge, but up to the present without revealing their role in the purification process. A study of the fauna of the sludge does, however, afford valuable information with respect to its presumptive activity.

The following is a typical analysis of the dried sludge: Loss on ignition, 75.2 per cent; mineral matter, 24.8 per cent; total nitrogen as N, 6.4 per cent; phosphate (P_2O), 3.8 per cent.

Tests of Value of Sludge as Fertilizer.—With the view of testing its value as a fertilizer, certain field trials have been carried out under the advice of Dr. E. J. Russell, F.R.S., director of the Rothamsted Experimental Station. A plot of land at the Withington works, upwards of an acre in area, was divided into 45 plots, the area of each of which was 108 sq. yd. Three crops—viz., spring wheat, mangolds, and cabbage—were grown in triplicate, so that each crop was cultivated on 15 plots, divided as follows: Three control plots without manure; three plots treated with sulphate of ammonia equivalent to 40 lb. of nitrogen per acre; three plots similarly with sulphate of ammonia equivalent to 80 lb. of nitrogen per acre; while the remaining six plots were manured with activated sludge such that the nitrogen added was equal to that contained in the sulphate of ammonia.

The results obtained with the spring wheat crop are recorded in the accompanying table:

CROP—SPRING WHEAT.

Treatment.	Corn					Straw	
	Plots						
	No.1, lb.	No.2, lb.	No.3, lb.	Total, lb.	Bus. per acre.	Total cwt.	Per acre, cwt.
Control unmanured	17	16	13	46	11 5	2¼	34
Ammonia sulphate 40 lb. N per acre	35	24	37	96	24.0	2¾	41
Activated sludge 40 lb. N per acre	36	31	22	89	22.2	2½	38
Ammonium sulphate 80 lb. N per acre	35	35	26	96	24.0	3	45
Activated sludge 80 lb. N. per acre	37	37	34	108	27.0	2¾	41

It will be seen that on the average the addition of the sludge has doubled the weight of grain produced, and further that the fertilizer value is equal to that of the nitrogen in the form of sulphate of ammonia, or, in other words, the nitrogen in the sludge is readily available for plant nutrition. This is in accordance with the results obtained by other investigators.

Unfortunately, both the other crops proved failures, the mangolds mainly by reason of too late sowing, and the cabbage as the result of prolonged drought immediately after planting and of the appearance of the cabbage maggot.

While no legitimate conclusions may be drawn with respect to these crops, it may be said that the plots manured with activated sludge showed 100 per cent increase over the control in the case of the mangolds, and from the manured cabbage plots about three times the weight of marketable (shop) plants were obtained as compared with the control plots.

In conclusion, it may be stated without hesitation that the two years' experience gained with this installation has demonstrated that the activated sludge process is a practicable process as applied to the purification of the sewage received at the Withington works.

It is also satisfactory to record that fears with respect to the impracticable amount of scientific control required for the successful operation of the process, with regard to the uniform distribution of air and in connection with the use of diffusers, have all been found to be without foundation. As a matter of fact, one of the outstanding features of the experience gained with this plant is the lack of trouble with diffusers. As stated previously, the plant has now been in operation for two years, and it has not been necessary to renew any of the 300 diffusers employed. Only eight have been removed from the tank (by undoing the union joint), and these have been replaced in good condition after brushing and blowing. The air pressure (3.1 lb.) is not increasing, so that there are no indications that the diffusers are becoming clogged. On the other hand, further information is required, particularly with respect to the conditions controlling the character and activity of the sludge with specific reference to the role of the higher organisms. This question is at present receiving attention on account of certain occasional difficulties that have arisen, due to the sudden and abnormal "bulking" of the sludge in circulation.

The important problem of dewatering the resultant sludge preparatory to drying has been studied with special reference to the use of centrifugal force both with and without preliminary treatment of the sludge. Comparative trials with filter pressing are about to be undertaken, and it is hoped that it will be possible to publish in due course the results of the research, for which the writer is only partly responsible.

Wells and the Permeability of Soils

From Engineering, London, Dec. 31, 1920.

In "recent" geological formations generally no other sources for a water supply will be considered than beds of sand or similar material. Beds of gravel are comparatively rare, and in the very great majority of cases a bed of sand is the source of supply. In the graphic analysis of a sample of sand taken from a bed of saturated sand, which it is proposed to be used as a source of water supply, the total per cent by weight of the sample passing through a sieve of a certain gauge is represented as an ordinate to the size of grain as abscissa, a coarse sand is indicated by a large abscissa compared to the ordinate, and a fine sand by a large ordinate compared to the abscissa. It is usual to grade the sand by a series of sieves of a certain number of meshes to the linear inch. Table I shows the relation between the sieve number, or number of meshes to the inch, to the corresponding diameter of the sand grains in milimetres. That is the width of the sand grain and not its length is assumed as the diameter.

Mr. Allen Hazen* classes different sands by what he terms the effective size of the samples. The effective size, or E.S., of a sample of sand is such that 10 per cent by weight of the material is of smaller grains and 90 per cent of larger grain than the size given. His reason for such classification is that in a mixed material containing particles of various sizes, the water is forced to go round the larger particles and through the finer portions which occupjy the intervening spaces, and so it is this finest portion which mainly determines the frictional resistance, the capillary attraction, and, in fact, the action of the sand in almost every way.

The uniformity coefficient of a sample of sand is the ratio between the sieve number separating the coarser 90 per cent from the finer 10 per cent, and the sieve number separating the finer 60 per cent from the coarser 40 per cent. If the grains of sand were all of one uniform size, the uniformity coefficient would be unity, and the porosity of such a sand in situ would vary as stated above between 25.95 per cent and 47.64 per cent. If smaller grains are introduced by suitable gradings the percentage of voids can be considerably reduced (See c, Fig. 2), and the uniformity coefficient would be increased. The uniformity coefficient may, therefore, be considered an indication of the ratio between the sizes of the larger and smaller grains; and is in a measure an indication of the porosity. In a good water-bearing stratum of sand the effective size lies between sieve No. 30 and sieve No. 60. The uniformity coefficient should not generally exceed 3.

TABLE I.

[illegible]	[illegible] in millimeters.
[illegible]	[illegible]
[illegible]	[illegible]
100	[illegible]
[illegible]	0.20
[illegible]	0.22
[illegible]	0.24
[illegible]	0.32
[illegible]	0.39
[illegible]	0.46
[illegible]	0.71
[illegible]	[illegible]
[illegible]	1.10
[illegible]	1.52
[illegible]	2.04
[illegible]	3.90

[illegible]

Example of Sand Analyses.—The following are examples of sand analyses, see Fig. 2:

Sand A.—Sample of sand taken from a stratum of fine sand struck by an experimental well. The yield from the stratum was small, and the sand was easily "blown" into the well at a moderate pumping head.

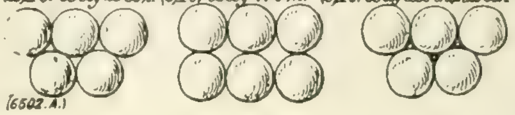
Passed through a No. 20 sieve, 100 per cent.
Passed through a No. 30 sieve, 98 per cent.
Passed through a No. 40 sieve, 96 per cent.
Passed through a No. 50 sieve, 92 per cent.
Passed through a No. 60 sieve, 52 per cent.
Passed through a No. 80 sieve, 8 per cent.
Passed through a No. 100 sieve, 3 per cent.
Effective size, 0.22 mm.
Uniformity coefficient, 1.31.

Sand B.—A coarse layer of sand struck below sand A yielded a more copious supply, and was not easily "blown" into the well.

Passed through a No. 6 sieve, 96 per cent.
Passed through a No. 10 sieve, 88 per cent.
Passed through a No. 16 sieve, 80 per cent.
Passed through a No. 20 sieve, 60 per cent.
Passed through a No. 30 sieve, 34 per cent.
Passed through a No. 40 sieve, 10 per cent.
Passed through a No. 50 sieve, 8 per cent.
Passed through a No. 60 sieve, 4 per cent.
Passed through a No. 80 sieve, 3 per cent.
Passed through a No. 100 sieve, nil.
Effective size, 0.46 mm.
Uniformity coefficient, 2.

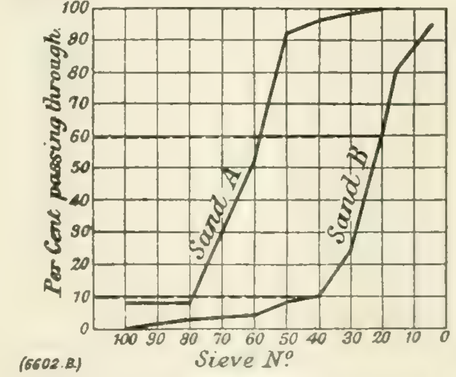
Flow Through a Porous Medium.—The flow of water through a porous medium depends on the diameter of the soil grains forming the medium, the length of the medium traversed by the water, the head or pressure producing flow, the porosity of the medium, and the viscosity which varies inversely as the temperature. If q = the rate of flow—

Fig.1. *Per Cent of Voids.*



(a) Porosity 25.95%. *(b) Porosity 47.64%.* *(c) Porosity less than 25.95%.*

Fig.2. SAND ANALYSIS.
Sand A. Finer 10% Sieve No. 81. Finer 60% Sieve No. 62. E.S.-0·22 m.m. UC-62/81-1·31.
Sand B. Finer 10% Sieve No. 40. Finer 60% Sieve No. 20. E.S.-0·46 m.m. UC-40/20-2.



Figs. 1 and 2.—Per Cent of Voids and Sand Analysis

$$q = C\frac{h}{l}A\frac{d^{2}}{wp}$$

When c is a constant,

h = difference of pressure at the ends of and just inside a cylinder of the material of length l.
A = area of the cross-section of the cylinder.
d = effective diameter of grain in mm.
p = a coefficient depending on the porosity.
v = a coefficient depending on temperature of the ground water.

Values of p for various per cent of porosity and values of w for various temperatures in degrees centigrade are given in the following tables:

Porosity. Per cent.	Value of p.	Porosity. Per cent.	Value of p.
[illegible]	[illegible]	[illegible]	26.26
27	74.05	[illegible]	24.09
28	65.93	[illegible]	22.11
29	58.90	[illegible]	20.30
30	52.48	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	17.27
32	41.76	[illegible]	15.96
[illegible]	[illegible]	[illegible]	14.75
[illegible]	[illegible]	45	13.71
[illegible]	[illegible]	46	12.75
[illegible]	[illegible]	[illegible]	11.82

It will be seen that the porosity of the stratum and temperature of the ground water have a marked effect on the flow.

μ COEFFICIENT OF VISCOSITY FOR TEMPERATURE [illegible] C.

t	μ	t	μ
0	0.0178	11	[illegible]
1	0.0172	12	[illegible]
2	0.0166	13	[illegible]
3	0.0161	14	[illegible]
4	0.0156	15	[illegible]
5	0.0152	16	0.0111
6	0.0147	17	0.0109
7	0.0143	18	[illegible]
8	0.0138	19	0.0103
9	0.0135	20	0.0101
10	0.0131		

The values for p and w are those ascribed by Professor Charles Slichter (19th Annual Report, U. S. Geological Survey, 1897-98).

$$\text{If } M = C\frac{d^2}{wp}$$

$$q = MA\frac{h}{}$$

If A h and l are unity, M is the quantity of water that would be transmitted in a unit of time through a cylinder of the porous medium one unit in length, one unit cross sectional area and under one unit head or difference of pressure at the ends of and just inside the cylinder. M may be called the "modulus" of the medium. The law fails to hold good for high pressures, as probably capillary flow is destroyed. The law fails to hold good for beds of coarse gravel exceeding about 3 mm. in effective size. Mr. Allen Hazen states that in such gravel beds the velocity varies as the square root of the head, and not directly as the head, and the velocity with a given head does not increase as rapidly as the square of the effective size. The influence of temperature is also less marked. Colonel Clibborn (Technical Paper 97) in experiments with a pipe 100 ft. long and 2.5 sq. ft. sectional area, packed with sand found that from heads varying from 1 ft. to 19 ft. the discharge curve was practically a straight line. He obtained the values of M in cubic feet per 24 hours for the following Punjab sands (comparatively fine sands) where the units were 1 ft. length of cylinder, 1 ft. head of water and 1 sq. ft. sectional area.

Khanti Sand.—Angle of repose 33° 3′. Specific gravity 2,652. Per cent of insoluble matter after sulphuric acid treatment, 90.8. Per cent removed by mechanical analysis, 42.3. M = 30.

Jamro Sand.—Angle of repose 33° 88′. Specific gravity, 2.704. Per cent of insoluble matter, 88.3 Per cent removed by mechanical analysis, 83.1. M = 42.

Temperature 67° F. to 74° F.

Mr. Beresford, in the same paper, states that M varied from 24 cu. ft. to 70 cu. ft. per 24 hours, according as the sand was tightly packed, porosity about 0.17; or loosely packed, porosity about 0.5.

Mr. Allen Hazen's formula to determine the flow of water through sand or other soils gives the value of M, the same units of 1 ft. being used, as

$$M = 3.28\,C\,d^2\,\frac{t + 10}{60}$$

Where

M is the flow in cubic feet per 24 hours.
d is the effective size of grain in mm.
c is a coefficient generally taken as 1,000 but which varies according to the condition of the sand whether clean or dirty, and is influenced by the uniformity coefficient.
t is the temperature of the ground water in deg. F.

On page 302, vol. xlviii, Transactions, American Society Civil Engineers, are given the results of experiments showing the influence of a small quantity of clayey or dirty matter in causing a diminution of flow through the sand. Messrs. Slichter ("Motion of Underground Waters," Water Supply and Irrigation Papers, United States Geological Survey, No. 69) and Baldwin Wiseman (Proceedings, Institution Civil Engineers, vol. clxxi, 1910, page 39) give formulae for the flow of ground water. These formulae may be more accurate in small scale experiments, but involve laborious work in determining coefficients. As in actual practice porosity, surface area per unit volume, and other qualities vary from point to point, Hazen's formula appears to be sufficiently accurate to be used for preliminary calculations, if samples of this water bearing stratum can be obtained. M, however, is best determined by actual yield tests of wells sunk into the water-bearing stratum under investigation.

The flow of ground water is exceedingly slow. Colonel Clibborn estimates that in the Ganjuli alluvium, composed of beds of sand, clay and loam, extending to a considerable depth, the slope of the ground water plane is about 1 in 250; and the velocity of a solid column of water of the same area as that through which percolation occurs is about one mile a year. Observations made by American and French engineers arrive at similar velocities. Experiments at Rohlfeist for a period of seven years show the velocity of ground water flow in coarse sand, glacier and river drift to be from 1.64 ft. to 13.12 ft. per day; in gravel from 16.4 ft. to 328 ft. per day.

The following figures are due to Professor Nazzani of Rome:

Values of M in cubic feet in 24 hours
Small gravel ....M = 2,075 ft., size about 2 mm.
Coarse sand ....M = 224 ft., size about 2 mm
Fine sand ....M = 40 ft., size about 0.2 mm.
Sandy soil ....M = 19 ft.
Sandy clay ....M = 10 ft.
Clay ....M = 2 8 ft.

Partition of the Load in Riveted Joints

By Dr. C. BATHO, McGill University, Montreal.

From Engineering, London, Sept. 3, 1920.

A riveted joint may be regarded as a statically indeterminate structure and a series of equations may be obtained for any joint by means of the principle of Least Work, giving the loads carried by each of the rivets in terms of a quantity K, which depends upon the manner in which work is stored in, or by the action of the rivets. This method has been applied to various types of joints and the modifying effects of non-uniform distribution of stress in the plates, unequal partition of load between the two cover plates and a difference in the modulus of elasticity of the cover plates and middle plate have also been considered. The theory has been verified experimentally by extensometer measurements on the outer surfaces of the cover plates of a number of double cover butt joints. The validity of this method of experiment was first determined by experimenting on a specimen in which the middle plate was made wider than the outer plates so that extensometer measurements were possible on the middle plate as well as on the cover plate. This experiment showed that the mean stresses in the cover plates could be determined from the strains on their outer surfaces. It was also shown that, at any rate after the first few loadings, the distribution of strain in the plates of the joint is not altered by repeated loadings. Experiments made on a number of specimens having a single line of rivets, and loaded in tension gave results in close agreement with the theoretical considerations. They also showed that the longitudinal stresses in a portion of the cover plate between two consecutive rivets are a maximum at the edges of the plates falling to a minimum along the line of rivets. The value of K for a joint having a given ratio of width of cover plate to rivet pitch was found to vary directly as the load and inversely as the area of cross-section of the rivets. An empirical rule was determined for its value in joints similar to the experimental specimens, but a general rule cannot be given until further experiments have been made. A thoretical estimate of the value of K for a rivet acting in shear gave results within the range of the experimental values. This fact, the validity test, and the general manner of longitudinal distribution of strain, all seemed to show that the rivets were acting in shear rather than by friction.

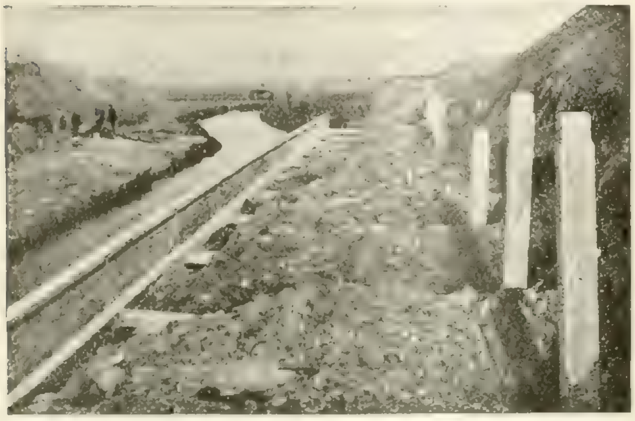
Both the experimental results and the theoretical deductions show that in a double-cover butt joint having a single line of rivets, the two end rivets and the two rivets on each side of the junction of the middle plates take by far the greater proportion of the load at all loads within that causing permanent deformation of the plates or rivets, the actual proportion decreasing slowly as the load increases. If the total area of cross-section of the cover plates is equal to that of the middle plates these four rivets take equal loads; if it is greater, the end rivets take greater loads than the others and if it is less the rivets on each side of the junction take greater loads than the end rivets. Members riveted to a gusset plate increasing in width from the first to the last rivets show a rather more uniform distribution. Most of the results given are discussed fully in a paper by the author, published in the Journal of the Franklin Institute (Philadelphia, Pa.), in November, 1916.

The results already obtained allow the general manner of partition of the load in any riveted joint, in which there is no eccentricity of connection, to be estimated, and it is hoped that, when further experiments have given general laws for the value of K, it will be possible to predetermine exactly the load carried by each rivet.

Unusual Application of Reinforced Concrete in Retaining Wall

From The Surveyor, London, Jan. 7, 1921.

The gasworks of the Stockport, England, Corporation are not contiguous to any railway sidings, and, in order to facilitate the working, the Gas Committee some years ago bought a piece of land bounded on the south side by the system of Cheshire Lines Committee, and on the north by a stream known as the Portwood Cut. This land it was decided to bring into use in order to cope with the increasing requirements of the department, and for some time a levelling up of the lower-lying land has been in progress, the material used being refuse and ashes from the gasworks. The ground on which the proposed works are situated is 25 ft. above the water level of the cut, and, after the work of filling had been commenced, it was found that the pressure of this surcharge load had the effect of tending to squeeze in the bank. Therefore it became evident that a retaining wall would be necessary to hold up the material, and it was decided to adopt Mouchel-Hennebique construction, which has been extensively employed in different parts of the country in the form of river and canal banks, sea-walls and kindred works, including structures for preventing landslides and other earth movements.


General View of Retaining Wall at Stockport, Showing Anchor Piles and Ties.

The wall at Stockport is approximately 164 ft. long, made up of king piles, 12 in. square by about 20 ft. long, and sheet piles, 8 in. by 15 in. in cross section by 15 ft. long. The king piles are driven at intervals of 15 ft., with the exception of four piles at one end, where the spacing is a few inches less. Between the king piles the spaces are filled by monolithic water-tight sheeting, formed by driving sheet piles in a continuous row, the piles being provided with a semicircular groove down each side, the cavity being filled with cement grout, which makes a perfectly water-tight joint. The top of the wall so constructed is finished with a continuous stringer, 14 in. wide by 10 in. deep, above this rising a parapet wall, 4 in. thick, finished with a continuous coping 9 in. wide. All these elements of the construction are in monolithic connection, and the whole is firmly rooted into the ground by the king piles. Therefore the wall is a perfect water-tight barrier capable of withstanding very heavy pressure without the least movement or deflection. But, as an additional precaution against displacement, and to increase its resistance to the thrust of the filling, the wall is tied back to a second line of king piles, each 14 in. square in cross-section, driven at distances varying from 20 ft. to 26 ft. behind the front row. The ties are 10 in. by 4 in. in cross-section, amply reinforced in tension. The front end of each tie is securely conected with the stringer and one of the front king piles, and the other end is connected with one of the rear king piles, each of the latter being provided with an anchor slab measuring 5 ft. by 3 ft. by 4 in. thick.

The ties constitute an interesting and unusual application of reinforced concrete. This combination is very rarely employed in the form of ties owing to the low resistance of the concrete to tensile stress, and it might perhaps be suggested that steel rods would be more suitable in the case now under consideration. It must be borne in mind, however, that the corrosion of steel used in the ordinary manner would involve future trouble, expense and serious risk, all of which are obviated by the adoption of ferro-concrete ties, these members being also capable of withstanding any transverse loading which may come upon them, and of acting as struts in case any pressure should be exerted against the face of the retaining wall as a result of unforeseen circumstances. Consequently the rigid reinforced concrete members are far more efficient than ordinary tie-rods could possibly be for the purpose of bracing together the wall proper and the line of king piles behind, and the advantage of permanent and uniform monolithic construction is also secured.

Timber trial piles were driven at selected points along the site so that data might be available as to the required length of the king piles in the front and back rows. The reinforced concrete piles of the lengths indicated were then moulded and seasoned. When the operation of driving these piles was in progress, the resistance and bearing power of the soil was found to vary considerably. Some of the piles were driven to their full depth, while others, such as those shown in the accompanying photographic view, reached thoroughly sound strata after penetrating for part of their length, and were left projecting above the ground, the upper part being cut off afterwards. Some of the reinforced concrete ties are to be seen in the same view partly covered by filling from the gasworks.

The whole of the work was carried out under the supervision of Mr. S. Meunier, the gasworks engineer, in accordance with working drawings furnished by Messrs. L. G. Mouchel & Partners, Ltd., of Westminster, who were represented during the conduct of operations by their district engineer, Mr. E. Kaylor, Assoc.M.Inst.C.E., of Manchester. The contractors were the Yorkshire Hennebique Contracting Co., Ltd., of Leeds.

Road Paving With Precast Concrete Slabs

By I. F. SHELLARD.

Borough Engineer, Taunton, England.

From The Surveyor, London, Feb. 18, 1921.

The usual procedure for laying concrete for road work has been to excavate to the required depth and lay the concrete in situ, and as it is necessary for that portion laid to be kept free from traffic for at least three weeks it can be readily understood that much inconvenience, and in cases great difficulty, is caused where it is laid in towns, owing to the impossibility of traffic being able to draw up to shops and business premises, and also where a road is too narrow to lay in two horizontal portions, and that this very real difficulty has prevented many municipal engineers from recommending their committees to carry out this form of road construction.

On fairly wide main and other roads this difficulty would not arise, because half the width of the road could be done at a time, but on narrow district roads it would be almost impossible to lay concrete roads unless the road could be entirely closed to traffic. To overcome this difficulty some method for making a concrete road other than in situ must be devised, and it may be of interest to know that the author has recently experimented with concrete slabs with a view to surmounting the difficulty. These slabs were made 3 ft. 6 in. long, 2 ft. wide and 5 in. thick, with smaller slabs to break joint. For experimental purposes some slabs were made wholly with broken stone as an aggregate, some with the bottom half of destructor slinker as an aggregate, the top half being broken stone, and some with a mixture of broken stone and clinker as aggregate. In every case the mixture was 3:1, 5:1; some slabs were reinforced, others were not. The slabs are laid, and covered a length of 20 ft. in a street where considerable traffic passes, the method of laying being to excavate to the required depth and bed the slab on a mortar composed of sand and cement 6 to 1, the joints being left open ⅛ in. and treated with tar and pitch filling.

These slabs have now been in position nearly three months and are standing well. This method is, of course, a little more costly than concrete laid in situ, but the method has many advantages—viz., the road can be opened to traffic a very short time after the slabs are laid. Should repairs to main sewers, etc., under the road be necessary, the slabs can be easily removed and relaid, and in the case of repair it is only necessary to replace the worn portion by relaying with new slabs. These facts undoubtedly give a great advantage and also a saving in cost over concrete roads laid in situ, for obviously much money would be spent in labor alone in cutting out a trench or worn piece of road so laid. It is not suggested that slabs should entirely take the place of in situ work, for there are many roads where the above conditions would hardly be worth considering, especially where there is a bad foundation.

Comparative Cost of Concrete Slab Work.—The following figures, it must be understood, are given only for the purpose of comparison. As far as possible correct costs have been obtained, but they would vary in different districts.

The cost of making an entirely new water-bound road suitable for main thoroughfare would be approximately as set out below. Foundation to be 9 in. thick, top metalling of broken stone 4 in. thick, gravel 2 in. thick.

	s.	d.
Excavation 1 ft. 3 in. deep at 6s. cu. yd.	2	6
Ballast foundation	4	0
Metalling (limestone)	3	0
Rolling	0	6
Per sq. yd.	10	0

s. = 24 ct., d. = 2 ct.

If granite be used for metalling, this cost would be increased to 11s. 6d. per yd. super.

If tar-macadam 5 in. thick be used, the cost would be increased 14s. per yd. super.

For a second-class road where perhaps the foundation would not be so thick and the ballast of an inferior quality, the cost may be reduced to, say, 9s., 10s. 6d., and 13s. per yd. super., respectively.

For a third-class road (such as on housing sites) the thickness of both the ballast and metalling could be further reduced, and the cost per yard super., say, 7s. 6d., 9s., and 11s. 6d.

For ordinary road repairs, i. e., scarifying and making up with 3-in. thickness of stone, an average of cost kept has given 3s. 9d. for limestone, 4s. 3d. for granite per yard super. for water-bound roads, and 4s. 9d. for tar-macadam.

Now as to the life of the above class of roads. This will vary, of course, to a very great extent upon the amount of traffic passing over particular roads, but for the purpose of making comparisons a fair average would be for water-bound limestone three years, granite four years, tar-macadam five years.

As to the cost of concrete roads, where an ordinary macadam road can be laid with 9-in. foundation it will not be necessary to provide any foundation for a concrete road, therefore the excavation will only need to be the thickness of the concrete.

FIRST-CLASS ROAD, CONCRETE 6 IN. THICK, REINFORCED.

	s.	d.
Excavation 6 in. deep	1	3
Portland cement concrete 3:1 5:1 (broken stone and gravel), 6 in. laid complete	14	2
Reinforcement laid	4	3
	19	8

SECOND-CLASS ROAD, CONCRETE 5 IN. THICK.

	s.	d.
Excavation 5 in. deep	1	3
Portland cement concrete 3:1 5:1 (broken stone and gravel), 5 in. thick, laid complete	12	0
Reinforcement laid	4	0
	17	3

THIRD-CLASS ROAD, CONCRETE 4½ IN. THICK.

	s.	d.
Excavation 4½ in. deep	1	3
Portland cement concrete 3:1 5:1 (broken stone and gravel), 4½ in. thick, laid complete	10	8
Reinforcement laid	3	0
	14	11

If clinker be used as aggregate for the bottom half of the thickness of concrete the cost (assuming that such material is obtained at a minimum price) would be reduced to, say:

	s.	d.
For first-class road per sq. yd.	17	7
For second-class road per sq. yd.	14	7
For third-class road per sq. yd.	12	8

As regards the experimental slabs before referred to the cost of making the—

	£.	s.	d.
31 sq. yds. was (or, per yd., nearly 18s. 10d.)	29	3	0
The cost of laying was (or, per yd., nearly 3s.)	4	11	3
Total cost	£33	14	3

This is equal to approximately £1 1s. 9d. per yard super.

It is very difficult to say what life a concrete road is going to give, but if properly surface treated ten years would be a fair length of time before anything in the nature of extensive repairs would be needed, and working upon this basis and comparing concrete road with the other classes of roads, we obtain the following interesting comparisons—

FOR A 10-YEAR PERIOD—FIRST-CLASS ROAD.

(Figures given in each case per square yard.)

		Ordinary limestone macadam.		Concrete road.	
		s.	d.	s.	d.
Initial cost		10	0	19	8
Repairs taken at a life of three years at 3s. 9d. per repair; 3½ at 3s. 9d.		12	6	nil	
	£1	2	6	19	8

SECOND-CLASS ROAD.

		s.	d.	s.	d.
Initial cost		9	0	17	3
Repaids		12	6	nil	
	£1	1	6	17	3

THIRD-CLASS ROAD.

		s.	d.	s.	d.
Initial cost		7	6	14	11
Repairs		12	6	nil	
	£1	0	0	14	11

For granite. This material would probably only be used on a first-class road:—

		Water-bound granite.		Concrete.	
		s.	d.	s.	d.
Initial cost		11	6	19	8
Repairs taken at life of four years at 4s. 2d.; 2 1-5 at 4s. 2d.		9	4	nil	
	£1	0	10	19	8

Tar-macadam:

FIRST-CLASS ROAD.

		Tar-macadam.		Concrete.	
		s.	d.	s.	d.
Initial cost		14	0	19	8
Repairs taken at life of five years at 4s. 9d. per repair; two at 4s 9d		9	6	nil	
	£1	3	6	19	8

SECOND-CLASS ROAD.

		s.	d.	s.	d.
Initial cost		13	0	17	3
Repairs		9	6	nil	
	£1	2	6	17	3

THIRD-CLASS ROAD.

		s.	d.	s.	d.
Initial cost		11	6	14	11
Repairs		9	6	nil	
	£1	1	0	14	11

Although the concrete road of the best material has been taken, the comparisons made show that in the long run concrete is cheaper than the ordinary roads now in general use, and even comparing the concrete block system as described at £1 1s. 9d. per yd. super. the cost compares most favorably.

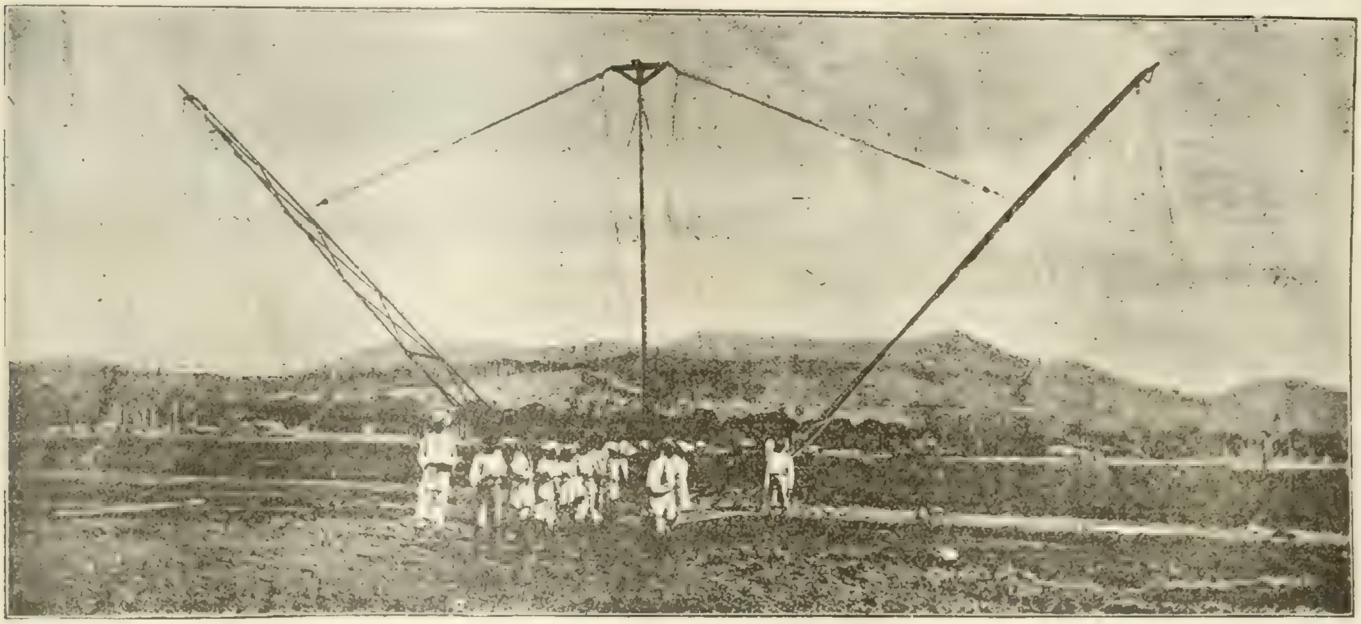
It is perhaps early to speak with any certainty as to adaptability of the concrete slabs for road work. If after fair trial of the experimental length satisfactory results are obtained, it is intended to recommend the council to lay further lengths of these slabs in preference to concrete in situ. Having in view the considerable amount of traffic which has already passed over the length laid, including daily passage of steam roller, traction engines, heavy carriers, etc., there is no fear as to the strength of the slabs, but to the possibility of their becoming loose with rocking on the bed. Clinker as an aggregate for the bottom half of the slab may cause some misgivings, especially as the reinforcement will be placed in that position, but probably any form of concrete road would have to be relaid before the damaging properties in the clinker had time to materially affect the cement and steel reinforcement.

In conclusion, the idea of concrete slabs for road work is not claimed as new, although the author has no knowledge of any place where they have been tried. It is, of course, obvious that slabs could not be laid on bad foundations, but if such system were adopted it would seem that slabs made half thickness with broken stone and half thickness with clinker as aggregates and reinforcement would give very excellent results and would not be out of the way as regards cost.

New Raising Tackle for Erecting Transmission Line Towers

From Indian and Eastern Engineer, Calcutta, August, 1920.

The construction of towers to carry the cables of the Hydro-Electric Works in the neighborhood of Bombay has stimulated the ingenuity of the erectors. These towers are placed in the most varied situations following no road. They may be located in a swamp, in the middle of a tidal creek, in cultivated land or in the primeval jungle, but whatever the station, satisfactory anchorage must be found and the materials along with lifting tackle carried to the spot by road, when there is one, or across country. It was found desirable to make the component parts as light as was consistent with strength, and equally so with the lifting tackle which had to be light, strong and practically foolproof. The accompanying illustration shows an outline of the tackle that was devised and recently patented by Mr. W. F. Doherty for the purpose. A light, hollow, tubular mast 35 ft. high is planted in the middle of the base of the tower and guyed to the four anchors that are firmly fixed in the ground. This mast has at the top a double crosstree in the form of an X, fitted with rings at the extremities for hoisting tackle. Two of the sides of the tower are built on the ground with their feet touching the anchors, and when complete are hoisted together into position, one balancing the other, and the upper ends of the tapering frames are temporarily attached to a platform with a hole in the center. The lattice on the other two sides of the tapered tower may now be filled in. A second mast of wood 26 ft. high is next raised past the cross-trees and through the hole in the platform, and stepped in a socket in the top of the lower mast. During this process a small platform is strung onto the upper mast and also a single cross head that rests on the top of it. To this is suspended by light tackles a small sliding platform to accommodate the workmen while completing the parallel portion of the tower. The four corner frames are now raised and bolted in place and the lattice work up to the pyramidal top is completed. The upper mast is now lowered by reversing the process used in raising it and the platforms removed. The lower mast is then raised to about half its height and passed out through the lattice work. The heaviest pull on the tackle during erection is equal to about one-fourth the weight of a side frame, the heavier end resting on the ground. The lifting tackle is thus of the lightest character, no rope exceeding ⅝ in. in thickness. When the work of erection began it took 18 men one day to build one tower, but eventually when the new method was introduced 18 men built 6 towers in one day, reducing the cost from Rs. 9 to Re. 1-8-0 per ton of material erected. There are still many towers in prospect without considering new work, and as this work has to be stopped during the monsoon which, in the area occupied by the undertaking amounts to 300 in. of rain, the importance of rapid and effective work will be understood. The workmen at first used ladders on the job, but these were soon abandoned for climbing on the lattice work.



Doherty's Patent Raising Tackle in Use on the Construction of Towers for the Hydro-Electric Works Near Bombay.

The Failure of Italy's Communistic Experiment

By ANDREW STEWART, M. I. E. E.,
Consolidated Pneumatic Tool Co., Ltd.

From The Engineering Review, London.

The age-long quarrel between the capitalist and the wage earner over the division of the profits which they create by their united efforts, has rarely had a more dramatic setting than in Italy. During the months of September and October an economic and social question suddenly became an acute political problem, and whether it will be settled by brains or bombs, or a combination of both, has yet to be determined.

Among a proportion of the Italian working classes there has for some time past been an openly expressed sympathy for Russia and its Soviet movement generally. This has been particularly noticeable in Milan, Turin, Genoa, Naples, Bologna, and smaller industrial centers. Newspaper reports were most conflicting; letters often disappeared, and when they did not, they took a week or more to reach their destination; so finally I decided to go and see for myself.

Milan was the first Italian town I reached, and, for a city in the grip of the revolutionaries, it seemed happy and content. True, policemen with rifles slung across their backs marched in pairs up and down the streets, and they were more numerous than hitherto, while, here and there, a bullet hole showed where street fighting had taken place. But Milan was as careless and happy as it ever was.

How the Crisis Came.—The conflict originated, as most troubles of this nature generally due, in a demand for a 50 per cent increase in wages by most of the employes in the metal working industries. The employers stated that the condition of industry generally did not permit of increased wages. Already the demand for the products of industry was diminishing, and any further increase in cost, due to higher wages, would still further reduce the demand, thus increasing unemployment. It was also pointed out that these constant increases in wages brought no real benefit to the worker; they tended only to increase still further the cost of commodities, and so raise the cost of living, in some cases in greater ratio than the increase in wages.

The men then started a "stay in" strike, and the employers retorted by deciding to close their works, because they could no longer operate them. The men then took possession of the factories, and, within a day or two, practically all the engineering and metallurgical works in Italy, totalling to about 300, passed into the hands of about half a million workers.

In most cases the men elected managers, foremen and administrative committees; in others the managerial and technical staffs, or part of them, were made prisoners and forced to carry on. In a few cases, some of the staff threw in their lot with the men. In all cases, however, the output and the policy of the undertaking were shaped by the workers.

One of the first results of the new management was that the workers, or a considerable proportion of them, began to "ca' canny," to arrive late, leave early, and generally make the most of their new found liberty. It was soon recognized by the more intelligent of the men that chaos was in sight, and the unions quickly framed new rules to deal with the situation, one of which was, "Whosoever comes late, or leaves work before the appointed time, shall lose his pay for the whole day's work." This and similar regulations showed that the workers had got rid of one alleged tyranny only to become slaves under a still more autocratic regime; yet this new autocracy had to be tyrannical in order to maintain order.

The Seeds of Collapse.—Notwithstanding this, work in some cases came to a complete standstill, because of the indiscipline of the workers. Further, many of the elected "bosses" were found to be very incapable, and, for one reason or another, "bosses" were elected and dismissed with surprising frequency. In some cases the more strictly the foreman or manager enforced the trades union edicts, the sooner he was deposed and a more pliable substitute found. In others the men had selected the most eloquent exponent of control by the workers, only to find that administrative ability and oratorical eloquence are not necessarily allies.

The most remarkable feature of this phase of the industrial revolution was the fact that some factories expelled the "red" men from the works as a result of a popular vote; indeed, this action provided the government with a valuable clue to the strength and popularity of the anarchists and bolshevists. Later on they acted on this information by arresting all the delegates who attended the Anarchist Congress at Bologna, towards the end of October.

The Giolitti government would never have dared to do this had not the action of the more level-headed workers revealed the fact that the extremists were an insignificant minority, and had neither the confidence nor support of the great body of workers. Many of the members of this anarchist congress were workers, with no more than the normal income of their class, yet they were found to possess large sums of money.

What terminated the revolutionary experiment was the discovery that there was no money to pay wages at the end of the week, nor was there any money to purchase raw materials. Sellers of material were not prepared to do business with people who apparently could not pay. A few managed to carry on for a week or two by selling what they could and applying the proceeds to pay wages, but it was soon found that the value of the product was insufficient for the purpose; in other words, the business quickly became insolvent.

They also found that they had to face problems of policy and administration, which they were incapable of solving; in short, they had taken over a great commercial machine which they could not run. In their anxiety to secure all the supposed products of their labor, they discovered that they could not even produce sufficient to pay the worker his normal wage, while the capitalist could do so, and even get something for himself. The capitalist could work the machine; they could not; and the "profits" accruing from the workers' control were a will-o'-the-wisp.

The Italian government, which had hitherto kept aloof from the dispute, now intervened, and, after preliminary negotiations with the trades union leaders, passed a law under which the workers were given a voice in the administration of the factories and a share in the profits. Further than this, workmen's co-operative concerns would, when under capable and efficient management, receive financial support from such banks as the Bank of Italy, the Bank of Naples, and the Bank of Sicily. These banks are National Banks, authorized to issue notes, and presumably have the government behind them in the venture.

One of the earliest works to take advantage of the new legislation was the Tabinelli works in Rome, constructors of railway rolling stock, which has become a co-operative undertaking, but in this case the capitalists stand in with the workers; thus experienced and efficient administration is assured.

The outstanding feature of the situation was that within ten to twenty days the workers realized the futility of democratic management. At one works, in which a richly carpeted and well furnished managerial office was occupied by two elderly engine fitters, the situation was discussed by the occupants and a younger visitor. The occupant of the managerial chair declared, "We have got everything except management; who will manage us?"

Enter the Peasants.—This industrial upheaval was followed by disturbances among the peasants, especially in Sicily, where extensive land seizures took place, but it is doubtful if these had the political significance which some newspapers attribute to them. Possibly external influences, chiefly bolshevist, were at work, but the system of land tenure in vogue there is admittedly bad, and has led to previous disturbances. The trouble in the rural districts should, therefore, be considered from quite a different standpoint, and is mentioned now only in order to make it clear that there was little or no relation between the industrial and agrarian troubles.

A feature of the organization for promoting industrial unrest was the opening in most industrial centers of wineshops where the gospel according to Lenin was propagated. These shops near the signboard, "Circolo Co-operatiro Proletario" (Proletarian Co-operative Circle). These establishments serve meals, and are frequented by workers during meal hours. The capital to start them came from some mysterious source, popularly supposed to be Russia.

One important factor in calming the unrest in industrial circles was the report of the mission sent to Russia by the General Confederation of Labor. The members of the deputation were ardent socialists, in wholehearted sympathy with the Russian revolution. This report said that the cities of Russia had fallen into moral and material misery, and the bolshevist government was unable to supply the minimum of the necessities which the community required. The peasants alone have derived more advantages than disadvantages from the change, only because in rural districts bolshevism had failed to make itself supreme.

The Russian capitalist system had certainly been destroyed, but nothing had been put in its place, and a group of communists, who did not number more than 600,000 people, had got control of the machinery of government and imposed a new and more terrible tyranny on the sixty million people. This report, which had wide publicity, convinced all but a few irreconcilables of the danger which lay ahead of Italy, and contributed a good deal towards the success of the proposal to form a parliament of labor, consisting of 150 members, representing in equal proportions the employer and employed.

This supreme labor council will have legislative as well as consultative powers, and will adjudicate on all questions involving the relations between employer and employed, such as discipline, working conditions, and the division of profits.

The labor unions have since formulated their terms, which are summarized under thirteen points, relating chiefly to a share in the management and "control" of the purchase of raw material, wages, selling prices, and profits.

It is realized, however, by the unions that in the present state of their development these are unrealizable conditions, and the workers have steadily receded from the advanced positions they have taken up. A most remarkable feature of the negotiations has been the reasonableness of the workers' attitude when the case for the employers was properly stated.

One of the outstanding features of the "revolution" is that, while it has fizzled out, it has achieved some notable results. It has demonstrated that an intelligent and well informed democracy is poor material for the revolutionary. A less intelligent democracy would have plunged Italy into an abyss of misery far beyond the worst that has ever occurred in Russia, for it is obvious that, while in an agrarian district a revolutionary change has an imperceptible immediate effect, since stocks of food and necessities generally are sufficient for a long period, in an industrial district the necessities of the workers can be met only by an immediate exchange of the products of industry for the necessaries of life, and anything which interferes with the flow of industrial products from the producer, or the return flow of food and other manufactured articles to the producer, must have an immediate and disastrous effect on the worker.

Effects of the Revolution.—Italian industry will settle down with no immediate benefit from the turmoil. One effect of the blow which industry has received is increased unemployment The basis on which industry rests cannot be quickly changed; the profits may be shared by the worker to a greater extent than formerly, but what if there are no profits? When the workers become disillusioned about the "huge" profits of the capitalist, will they once more display dissatisfaction by striking against the employer who cannot make profits? Industrial unrest will always exist, but it may take a new form.

The works that cannot make profits will probably lose its workers, the factory across the street which does make profit will get as many employes as it wants; it will be able to pick and choose, leaving the poorest workers to the factory that does not make profits. This process will only make the unprofitable factory still more unprofitable.

New businesses could probably never get a start. It is the exception to find a new business that pays from the beginning. The capitalist often loses money for years in a new venture. Under profit sharing conditions, could he get a sufficient number of reliable employes to enable him to carry on? They would be so dissatisfied with the results of their labor that, even if they did work, they would be less efficient than employes in works where there are profits to divide. Dissatisfied workers are seldom efficient workers, and how is a new business to struggle into success with dissatisfied workers?

This problem of new or temporarily profitless business is a serious one to all undertakings where profit sharing is adopted. The problem of losses is still more serious; if the business loses money, who suffers? The capitalist, the state, or the workers? A capitalist may be willing to lose money for a few years in the hope of ultimately reaping a rich reward, but he will not risk it if he must give away a large share of that reward. If the state guarantees the capitalist against such losses, the taxpaying public have to foot the bill, and are they likely to submit to taxation to support such losing industries? Who is to determine whether these losses are legitimate or not, or if it is worth while continuing to support a losing business? Yet every capitalist must face losses—temporary, no doubt, but often very discouraging; and only an indomitable courage and determination to win carries him through. This is especially true of new businesses.

The nation with no new business ventures has got well along the road to ruin, but these new undertakings are almost always a drain on the resources of the capitalist, who can hardly be expected to stand all the losses and get only part of the gain.

Concrete Under Heat.—In the discussion which followed Professor Lea's paper at the British Association on "Testing Materials at High Temperatures," reference was made by several speakers to the fire-protection of reinforced concrete structures. Professor Hudson Beare thought it would be interesting to know to what extent the steel is protected by the concrete from the high temperatures to which it would otherwise be directly exposed, and he also suggested that if the concrete, on being cooled in the ordinary way by a jet of water, scaled off and exposed the steel to the action of flame the results might be serious, especially in the case of columns, and might lead to the collapse of the structure. It may be pointed out here that well-authenticated tests, notably those of Professor Woolson, show that steel is very efficiently protected from excessive heat by a moderate thickness of concrete. Thus, it has been found that steel embedded at a depth of 2 in. from the surface of concrete attained a temperature of only from 200 to 300° F. after the concrete had been heated to 1,500° F. for an hour. As for the possibility of scaling in cases where concrete is cooled by water after a fire, the risk of scaling can be obviated by the adoption of suitably prepared concrete. Moreover, the experience gained as a result of many severe fires shows that scaling does not lead to failures, although of course the original strength of the columns so affected must be considerably reduced. Professor W. H. Watkinson made the novel suggestion that the steel in ferro-concrete structures might be kept cool by employing the metal in the form of tubes through which water could be automatically circulated. For structural reasons, this device would certainly be undesirable although not impracticable; but in view of the insulating properties of the concrete anything of the kind is superfluous.—Times Engineering Supplement (London), September, 1920.

Quay Wall Construction with Reinforced Concrete Sheet Piles

From La Genie Civil, Paris.

In 1916 the Moroccan Public Works Department, under the direction of French government engineers, decided to construct, at Kenitra, on the Sabou River, Morocco, a permanent wall of a length of 1,250 m., of which 250 m. were to be carried out immediately.

This work was to be executed by a series of reinforced concrete piles driven into the ground, and united at the top by a system of beams and ties, the whole of which was to be covered by a deck. This was to be strong enough to carry moving cranes weighing 3 tons, and having a radius of 12 m. Also trains were to circulate on this deck.

Towards the end of 1916 the work was put in competition and one of the principal contractors who competed for the work thought it advisable to present an alternative scheme prepared by Mr. L. Ravier, late engineer of the French Naval Department, in accordance with the Coignet-Ravier System of sheet piles. This scheme produced an economy of about 40 per cent on the concrete, and 55 per cent on the steel over and above the original scheme, and, although the former required a certain amount of filling, it was adopted. The detail plans were prepared by Mr. Ravier, in accordance with the instructions of the Public Works Department.

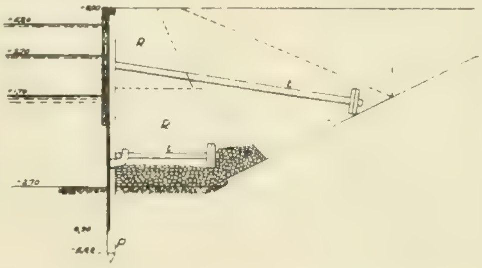


Fig. 1.

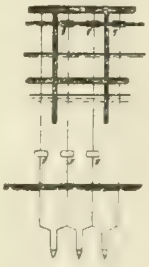


Fig. 2.

The Sheet Piles.—The wall is composed (Figs. 1 and 2) of a row of Coignet-Ravier sheet piles, each of which has a rectangular body (pile) of 45 by 30 cm. and 12.20 m. in height. For a height of 11 m. this pile is fitted with wings or panels, having a thickness of 10 cm., giving a width of sheet pile (P.) equal to 1.24 m.

These sheet piles are driven consecutively alongside of each other, each being guided by the neighboring pile by means of pieces of wood bolted to the edge of the wing, and which form a guide engaging at the top of the wing and gradually following down as the pile is being driven.

This system does not necessitate that the piles should be driven to a set. It simply forms a wall sufficient to resist horizontal pressure, but only calculated to support slight vertical pressures.

The length to which the piles are to be driven was first fixed by means of timber test piles. This length was chosen slightly less than that required for a perfect set, but sufficient, however, to fix the piles into the ground in a solid manner, so that they may stand upright during the execution of the work. It is easy, therefore, to regulate the driving of all the piles to the same level. · The stability of the wall is ensured by means of land ties and anchor plates.

The section of the reinforcement of the sheet piles was determined in such a manner as to give them the necessary amount of resistance to bending. The wall was, therefore, calculated as a vertical reinforced concrete floor in which the horizontal pressure, due to the filling, takes the place of the superload on the floor, the wings of the sheet piles acting as floor slabs and the piles as beams. The joints of the land ties act, of course, as points of support. The calculations were made in accordance with the rules of Mr Resal, general inspector of roads and bridges, and in accordance with the French Regulations of 1906 for reinforced concrete.

A filling composed of stone R, R' (Fig. 1), was placed immediately at the back of the wall to a thickness of about 8 m. at the base, and 2 m. at the top. The dotted lines indicate the various fillings. The filling composed of stones has allowed the thrust to be calculated with a slope of 45 degrees above the water and 40 degrees below the water level. This has had the effect of reducing the efforts, and, consequently, has produced an economy in the reinforced concrete, at the some time as producing better conditions of stability.

As this work was constructed on mud, it has been necessary to take into account, in the portion of the piles below the dredged level, that relatively much greater pressure would be exerted corresponding to a slope of only 20°.

Methods of Anchorage.—Each sheet pile is maintained in its height by two steel land ties, t, t^1 (Fig. 1) surrounded with concrete. These unite the sheet pile to the anchor plates in reinforced concrete, the latter being simply placed freely in position and resting on the slope of the ground, and afterwards surrounded with filling. The lower tie t is fixed to the sheet pile by means of a pivot in reinforced concrete running through its thickness and by means of which it is attached to two hooks in reinforced concrete supported by the sheet pile, the whole of which forms an articulation which allows the tie to hook properly, and, at the same time, to take the required inclination, in accordance with the slope of the ground on which the anchor plate is resting at its other extremity. The fixing of the pivot to the hooks is made below low water level

Concerning the fixing of the higher land tie, which is above water level, a semi-articulation has been used, in accordance with the type usually employed by Mr. Mesnager, Chief Engineer of Roads and Bridges—namely, by means of a flattened tie, in order that flexion should take place easily.

Construction Features.—The sheet piles at Kenitra weighed about 6 tons each and were driven by means of an American pile driver, the tup of which weighed 1,500 k.g. This pile driver was fitted with a steel winch and on a pontoon against which barges loaded with piles could be moored. The guiding of the piles, which was done by means of wooden guides, fixed temporarily to the edge of the wings, offered no difficulty.

After the driving of the piles, the lower ties were placed in position, and afterwards the lower part of the stone filling was carried out. By lowering the ties along the projection at the back of the sheet piles it was possible to hook them automatically to the reinforced concrete hooks provided for the purpose. The stone filling prevented the ties from getting out of position. Once the lower ties were in position, the filling was completed methodically by first loading up the anchor slabs of the lower ties, then gradually filling up at the back of the wall.

The next operation consisted of placing in position the upper ties at low tide. After this the articulations of the Mesnager type uniting the ends of the ties to the sheet piles were carried out. After these ties had been fixed the remainder of the filling was executed as previously. Finally, the remainder of the filling was placed in position. To finish the work the top of the sheet piles were united by means of a continuous beam in reinforced concrete. No attempt was made to make the joints water-tight. In fact, weep holes were left in the wall in order to prevent an accumulation of water at the back of the wall, and in order to reduce the pressure.

The quay wall was completed by means of timber fenders fixed in a suitable position.

Once the work was terminated, it was tested on Dec. 4, 1918, on a length of 60 miles by means of a superload of sand weighing 3,000 k.g. per square meter, and the results were found to be absolutely satisfactory. Since then the work has been in continuous use.

This method of construction, which has produced an economy of 40 per cent for the concrete and over 50 per cent for the steel, as compared with a reinforced concrete deck supported on piles, is also productive of a similar economy as compared to a wall in ordinary piles and sheet piles constructed in reinforced concrete.

The economy, so far as the concrete is concerned, is due to the use of T-sections, which produce the same resistance with very much less concrete than sheet piles of constant thickness throughout their height. The economy of the steel may be attributed to the fact that the arrangement of the anchor ties constitutes an important point in the system of construction, as it produces several points of support throughout the height even below water, which has the effect of considerably reducing the bending moments which have to be taken by the vertical elements of the work.

Diagram for Use in Designing Steel Pillars

By EWART S. ANDREWS.

From The Engineering Review, London

The accompanying diagram has been found useful by the writer in the design of steel pillars.

The formula, upon which the diagram is based, was derived by the writer by mathematical analysis similar to that employed by Mr. J. Mitchell Moncrieff in the derivation of his widely used formula.

The method of treatment consists in assuming that the pillar is initially slightly bent, the resulting eccentricity being proportional to the square of the length of the pillar and inversely proportional to the transverse dimensions of the pillar.

The resulting deflection is then calculated by mathematical analysis and the combined stress due to bending and direct stress are equated to the yield point stress of the material. The load required to produce this stress is regarded as the ultimate strength of the pillar.

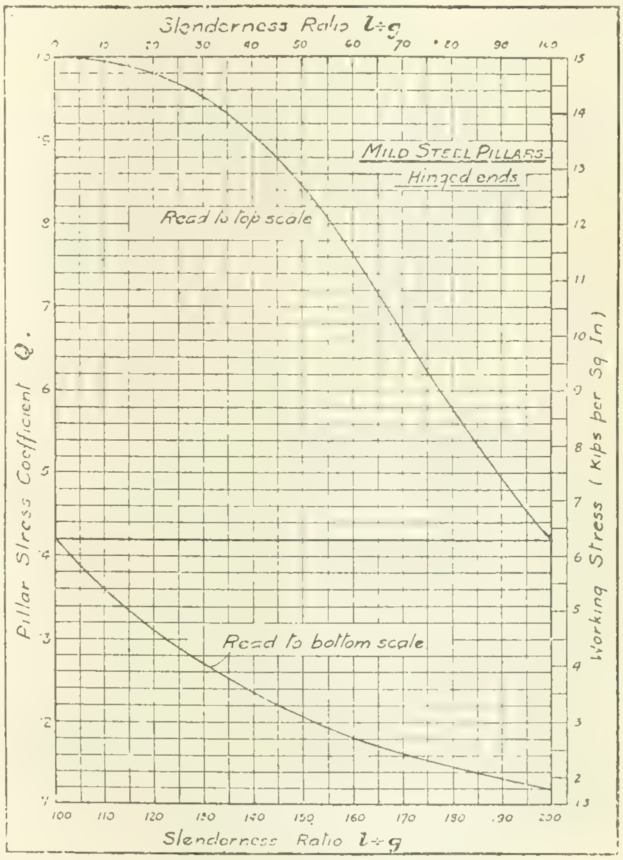


Diagram for Design of Steel Pillars.

The following formula results:

$$\frac{c_p}{c_y} = Q = \frac{59.81 + c_e - \sqrt{(59.81 + c_e)^2 - 180c_e}}{90}$$

where c_p = ultimate stress per square inch of pillar
c_y = yield point stress of material
c_e = Euler's stress on the pillar in thousands of pounds per sq. in.

The resulting stresses will be found to be in very fair agreement with those obtained from Moncrieff's formula.

For fixed ends take slenderness ratio $= \frac{l}{2g}$; for one end fixed and one end hinged take slenderness ratio $= \frac{.71}{g}$

The method of dealing with pillars by means of the Pillar Stress Co-efficient brings out the true nature of the effect of buckling tendencies upon the strength of pillars, and is the most useful method to adopt in designing for various cases in which different factors of safety have to be employed.

If, for instance, the Pillar Stress Co-efficient given by the diagram comes to .6, then the safe stress per square inch of pillar will be .6 of the safe stress in compression for short lengths.

Caisson System of Reinforced Concrete Jetty Construction at Cape Thevenard, South Australia

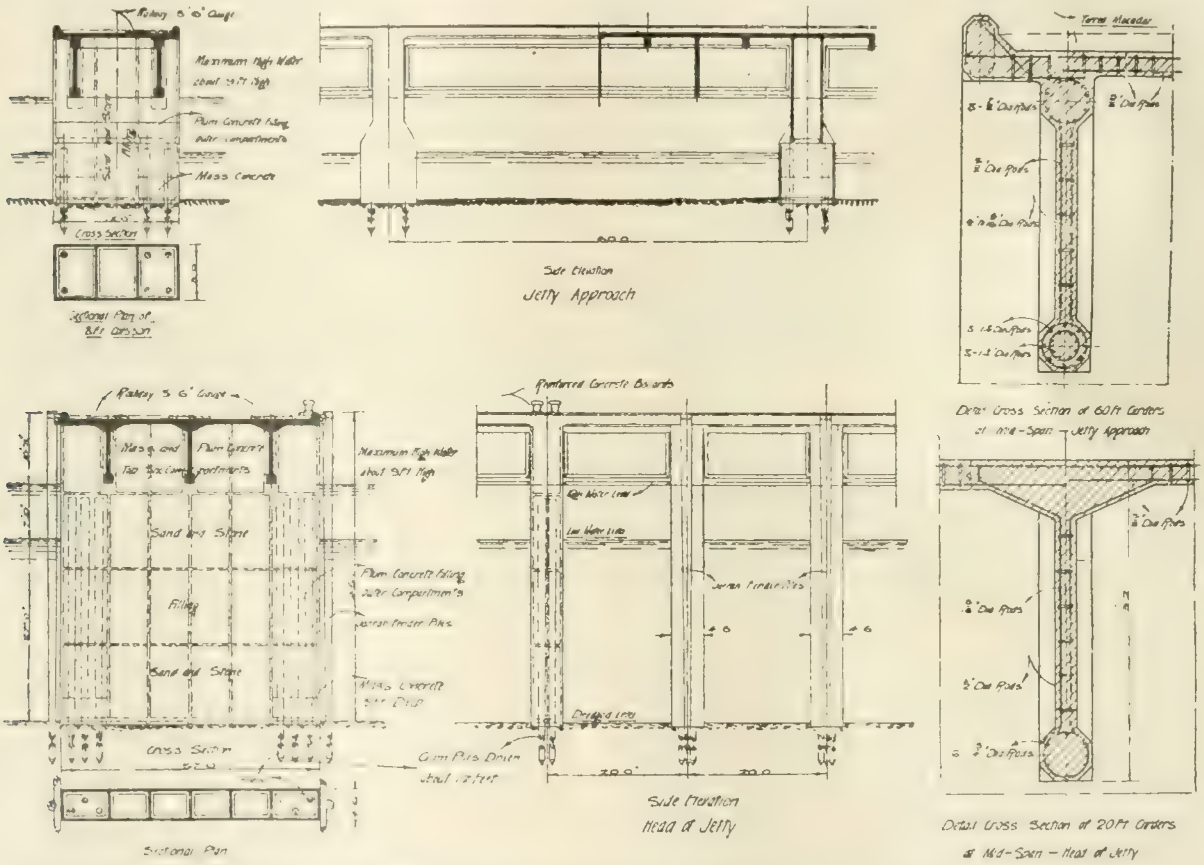
By E. G. Stone.

From Commonwealth Engineer, Melbourne, Australia.

At the end of 1914 tenders were called by the South Australian Harbors Board for the design and construction of a jetty of about 1,200 ft. long at Cape Thevenard, on the west coast of South Australia, in the Great Australian Bight. Previous experience with the Sydney Harbor Trust led to the conclusion that jetties built of reinforced concrete piles were not suitable for heavy maritime conditions. A proper and separate fendering system is necessary where vessels of anything over 2,000 tons d. w. capacity berth against same, and even when the vessels are smaller the concrete plies must be of sufficient strength to take up the shock of berthing vessels. If this is not done, cracks occur below the water line which are not seen and in time the structure must become unsound and unstable. Hence it was suggested that caissons, spanned by deep girders, should be adopted for the piers.

The design submitted was as follows:—For the approach: Eleven 60-ft. spans; caissons 18 ft. by 8 ft. by depth as required; width of deck between curb 16 ft. The girders adopted for the approach spans are 9 ft. 2 in. from top of deck slabs to underside of lower boom. For the jetty spans: Two 53-ft. spans and twenty 20-ft. spans; the caissons for the former are double and for the latter are single, and were cast on shore on launching ways. They are 37 ft. by 4 ft. 6 in. by 34 ft. high, and were cast on their flat with valves on the bottom end, through which water was allowed to enter. They then upended themselves into a vertical position and were drawn by steel ropes connected to winches into distance frames or spacers. Sufficient water was then allowed to enter to sink them vertically into their correct position.

The caissons were cellular, and into each of the two outer chambers three piles were driven and surrounded by poor concrete except for the lower 3 ft. and the upper 3 ft, for which a 1 : 2¼ : 4 mixture was used. The other chambers were filled with sand and stone to give weight and stability. The depth of water at the jetty spans is an even 27 ft. at L.W.O.S.T.; the range of tides at the jetty spans is a maximum of about 9 ft. under heavy winds. The caissons, after filling, were topped up to a height of about 43 ft. to underside of deck slab. There are three girders in the cross section of the jetty spans, which were cast on the deck of the approach spans; the upper booms of girders were not cast on the shore, but the necessary reinforcement projects and forms a bond. The girders thus cast as units were brought up on a carriage under a jib crane at the head of the work and lowered into properly prepared seats. The top booms of girders and decking were then cast in one operation with curbs and reinforced concrete double-headed bollards. The girders for the 20 ft. spans are of the same depth as for the approach spans. The idea of building such deep girders for the smaller spans was (1) to allow a solid bracing in lieu of building and casting troublesome small members, (2) to reduce the boom stresses, and (3) to preserve the same line of girders throughout the whole work. The structure is designed to carry a deck load of 5 cwt. per square foot, and a locomotive with a tender of 45 tons, or a wheel base extending over 30 ft. 6 in.


Railway 5' 6" Gauge
Maximum High Water about 9 ft. High
Plum Concrete Filling Outer Compartments
Mass Concrete
Cross Section
Sectional Plan of 8 ft. Caisson
60.0
Side Elevation
Jetty Approach
Terra Macadar
Detail Cross Section of 60 ft. Girders at Mid-Span — Jetty Approach
Railway 5' 6" Gauge
Mass and Plum Concrete Top ... Compartments
Maximum High Water about 9 ft. High
Sand and Stone
Plum Concrete Filling Outer Compartments
Filling
Jarrah Fender Piles
Sand and Stone
Mass Concrete
Cross Section
Sectional Plan
Reinforced Concrete Bollards
High Water Line
Low Water Line
Jarrah Fender Piles
Dredged Level
Gum Piles Driven about 12 feet
20.0
20.0
Side Elevation
Head of Jetty
Detail Cross Section of 20 ft. Girders at Mid-Span — Head of Jetty

General Design and Details of Reinforced Concrete Jetty at Cape Thevenard, on West Coast of South Australia.

The jetty, now completed, is perhaps as fair an example of jetty construction as has been done, but, as is well understood, designs are not only to be considered from the point of view of the completed structure, but from the building aspect as well; that is to say, commercial practicability has to be taken into account. Where heavy seas, with waves up to 6 ft. in height, occur, building upon caisson system needs special precautions. There is, of course, not much difficulty in providing sufficient strength to hold the caissons as far as spacers and distance frames are concerned, but the constant movement of the waves gradually breaks all fastenings, and should a storm occur just after a caisson is placed, losses must be allowed for, unless the caisson is designed to be stable in itself. Apart from this, the caisson design is sound in principle, and offers a good opportunity to engineers for meeting the many difficulties that present themselves in designs of marine structures.

The material available for the concrete of the Cape Thevenard jetty was not the best. The stone is of excellent quality for compressive strength, being granite procured on the foreshore, but this stone has not a good adhesion. The sand, however, seems to be a disintegrated limestone—too fine in grain for the best marine work. But, strangely enough, the concrete in a continuous deck, over 1,000 ft. long, shows no signs of cracking, although no expansion joints have been allowed for.

Concerning the lasting qualities of concrete in salt water much can be written. Over 15 years' experience has convinced the author that, with suitable cement and proper regard to relation of density as compared with compressive strength, Portland cement concrete can be relied upon to last apparently an indefinite period. Concrete tested after 15 years' immersion in salt water shows an increase in compressive strength, and the reinforcement when properly protected no sign of deterioration.

Concrete Block Lining for Fuel Oil Tanks

From Concrete and Constructional Engineering, London.

Owing to the wartime difficulty of obtaining in India the steel reinforcement generally used when a concrete face is to be applied to a large area, other methods had to be considered in the construction during the war of reservoirs of 2,500 tons capacity each to store the liquid fuel used on the locomotives in the Karachi district of the North-Western Railway. The tanks are 8 ft. 6 in. high, and 60 ft. by 40 ft. interior measurements, and were constructed under the superintendence of Mr. N. Pearce, executive engineer to the North-Western (India) Ry. In considering an alternative to reinforce concrete, mass concrete was ruled out owing to the strict supervision necessary in the mixing and depositing of this type of construction, the forms which would be required and the necessity of providing expansion joints.

The thickness of the concrete face to be applied was 9 in., and it was finally decided to use blocks 11⅞ in. by 5⅞ in. on the face by 4½ in. deep. The small size was adopted so that the blocks would be easy to handle and also bond in with the brick work. They were laid like ordinary bricks, on edge, two bricks forming the 9 in. lining required. The blocks were at first made by hand, but it was found that these did not attain the requisite compactness of density, and this method was discarded in favor of machine mixers and a "Jagger" vibrating table for making the blocks. As the lining was required to be proof against the absorption of oil fuel a rich mixture was decided upon, as follows: 1 part cement, 1½ parts clean sharp sand and 3 parts clean gravel screened to ¼ in. In laying the hand-made blocks a mortar of neat cement was used, but this was found to be unsatisfactory, as if made wet enough to work easily into the vertical joints it was too wet to stand up in the joints on the sloping sides of the tank; shrinkage cracks also occurred during setting. The mortar used in laying the machine-made blocks was composed of 1 part cement to 1 part sand, and this was found to be satisfactory. The blocks were laid like ordinary brick work, breaking joint as much as possible.

Tests were carried out to ascertain how far the blocks were impervious to the penetration of the liquid fuel, sample blocks being immersed in the oil for a period of seven days. These tests showed that with the hand-made blocks the oil penetrated to a depth of 1⅞ in. in the week, with the exception that no appreciable penetration took place on the top face of a block made with a very wet mixture. This was due to the cement in the block working upwards whilst setting, with the result that the top face was practically coated with a layer of neat cement. With machine-made blocks the penetration in the same period was found to be only about ½ in., and fairly regular on all faces. On the inside surface of the tank, the blocks are covered with a final coating of cement plaster, the hand-made blocks with ⅝ in. of neat cement and the machine-made blocks with a mixture of 1 part cement and 1 part sand to a depth of ⅝ in.

Observations as to the loss of the contents of the tanks by percolation through the walls show that the losses tend to diminish as time proceeds. With hand-made blocks and neat cement plaster, no measurable loss was found in a period of 20 days after the tank had been in use for some few months, and observations on a tank constructed with machine-made blocks and a lining of 1 part cement and 1 part sand show a loss of 0.05 per cent of the contents during a period of 43 days.

Method of Remedying Railway Slip in Clay Cut

From The Railway Engineer, London, February, 1921.

The North Eastern Ry. (England) had considerable trouble with slips occurring on the Byken and Percy Main branch, which generally took the form shown in Fig. 1. The remedy adopted in this case was the clearing away of a width of 15 to 20 ft. along the toe of the slip, or to a sufficient width and depth until the good undisturbed clay was met with both downwards and sideways. This was followed by the burning of the clay on the site where it failed.

A good fire of wood and coal was lighted after the excavation was made to solid ground, and when this was burning well the clay which had come down the slip was thrown upon the fire from both sides, in layers of 12 to 30 in., alternating with other layers of small coal, until a height of 8 to 12 ft. was made up of the alternating layers.

A foundation for the fire was formed of heavy slag and hard stones, roughly laid on the solid ground, and this was found to give a good draught for combustion. The position of the heaped mass of material is shown in Fig. 1. The method adopted for burning bricks in kilns was followed, the fire being continually extended along the bottom of the slope at one side while it was dying down at the other.

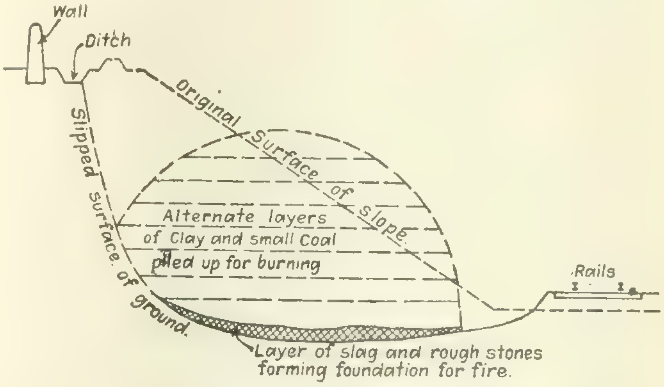

Wall
Ditch
Original Surface of Slope
Slipped surface of Ground
Alternate layers of Clay and small Coal piled up for burning
Rails
Layer of slag and rough stones forming foundation for fire.

Fig. 1—Cross Section of Slip in Cut Showing How Clay Was Heaped for Burning.

The clay being hardened in this way was taken back and refilled into the void in the slope as quickly as it became cool, the slopes being trimmed off at the finish as might be required. The material, after being burned, was found to occupy from 20 to 25 per cent more space than the orginal material, and a considerable quantity of burnt clay had to be deposited elsewhere.

In one or two cases where the excavation had not been taken out sufficiently deep the slope failed a second time, and this could only be remedied by digging out the slip once more and making sure that the bottom of the slide was reached.

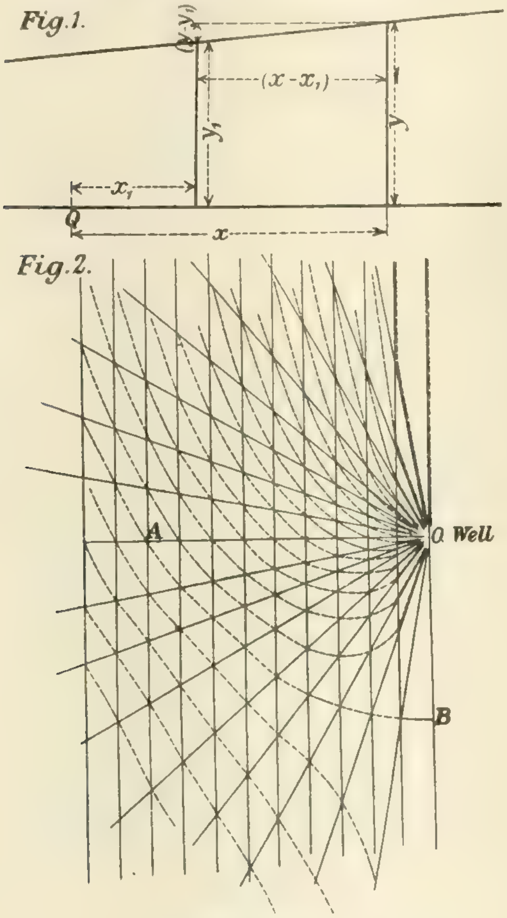
Similar slides occurred in clay embankment, and these were treated in the same way as the cuttings, except that the burning was carried out in narrower sections.

New Type of Filter for London.—A new and more rapid type of filter is being tested by the Metropolitan Water Board of London, according to Municipal Engineering (London), of March 3, 1921. The first unit is now being installed at Barn Elms at an estimated cost of $238,000. At times of maximum demand there has been difficulty in obtaining sufficient water for the large district supplied from Hammersmith pumping station. There are 19¼ acres of slow sand filters at Barnes and 5 acres at Barn Elms, delivering a maximum of 37¼ million gallons a day. Five more million gallons a day are required. This quantity would be afforded by a rapid primary filter plant of a capacity of 15 million gallons a day, the water from which could be passed on to the existing slow sand filters and dealt with at about double the present rate. The first unit, referred to above, should yield 7½ million gallons, and a second unit will be added if this proves to be a success.

Wells as a Source of Water Supply

From Engineering, London, Feb. 11, 1921.

Where a well or several wells are proposed to be used as a source of water supply to a village or town, the tributary area of the well particularly if sunk into recent alluvium, requires careful investigation. If a supply of water is required for irrigation occasional failure is not disastrous. In the "insecure" tracts of Deccan India where irrigation wells and tanks fail one year in every 8 or 10 years, the crops obtained during the other years more than compensate for the loss of one year's crops. Scarcity or famine is only experienced after a failure of the rains in two or three successive dry years. In the case of a public water supply, failure of supply cannot be regarded with the same equanimity; so that the minimum supply of a source, and not its average supply, should be taken as the available yield from the source. In areas of more or less constant moisture, where the source of supply is from wells, it is possible that the natural ground storage may render the yield ordinarily quite uniform, so that the draught from the wells can more or less exceed the minimum yield, and the effect of dry years be disregarded; yet in areas of uncertain rainfall, particularly where the depth of the water-bearing soil is not great, and where the proposed draught from the well nearly equals its estimated yield, it will be advisable to neglect this element of ground storage.



Figs. 1 and 2.

The tendency is to waste and in arid climates where potable water is valuable the people must be accustomed at the initiation of a public water supply to economy. A constant draught in excess of the yield from a well may in a year of extreme dryness result in failure of supply; and if the ground water store is depleted it may take months and years for the water to accommodate it, say, to the new conditions. Even in this humid country numerous wells along the coast have been abandoned, owing to the constant draught, in excess of the yield, draining the soil of the storage of past years, so much so that the salt water from the adjacent sea has entered the depleted soil, and rendered the wells brackish, a condition from which, as far as our present experience goes, a well never recovers.

The Tributary Area of a Well.—Turning to the tributary area of the well, we may consider a pocket or basin of water-bearing soil surrounded on all sides, except at the surface by impermeable soil, the only source of supply to the ground water being that portion of the rainfall on the exposed surface which percolates down to and is retained by the ground water. The supply that can be expected from this basin will normally be the average annual rainfall, less calculated or observed losses. These losses are chiefly transpiration by vegetation, and soil evaporation, the latter depending on the nature of the soil, and the depth of the ground water-level below the surface. If the climate is arid, and where the variation between the years of low rainfall and the average rainfall is great, it will be safer to assume as the supply available, the mean rainfall of the three successive driest years, less the losses mentioned above. As a particular example, if the basin was situated in the area of insecure rainfall in the ceded districts of the Madras Presidency and Deccan India, the statement below shows statistics of rainfall at five towns scattered over that area:

Name of town.	Mean annual rainfall.	Maximum rainfall.	Minimum rainfall.	Mean of the lowest three consecutive dry years.
	In.	In.	In.	In.
Bellary	19.0	35.02	7.23	13.09
Adoni	26.28	53.31	11.25	19.37
Auantapur ...	20.29	37.12	3.90	14.52
Cuddapah	32.01	58.50	9.46	19.99
Kanigiri	24.49	38.84	6.45	16.98

The number of periods of consecutive three dry years in which the mean of the three years is below the mean annual rainfall is seven, during the 48 years' records.

It is obvious that a water supply to any of these towns from percolation wells sunk into water-bearing strata, which depend solely on that portion of the rainfall which percolates to the ground water for its replenishment, will be extremely precarious. In a year of minimum rainfall it is probable that the whole supply will be lost by soil evaporation, and in the periods of successive dry years the replenishment to the ground water must be very small indeed. So that unless the water-bearing soil is of great depth, and the area of the exposed surface of the basin comparatively large, other sources of supply should be looked for; or the supply to the town restricted to the estimated minimum yield. The number of wells required to obtain this supply from the area under consideration will depend on the size of grain of the water-bearing soil, and on its porosity. The larger the size of grain and the greater the porosity the less the number of wells required.

In the case of ground water flowing to some distant outlet, let y be the height of the level of the ground water plane above a horizontal impervious stratum, and x the distance from any origin 0 (vide Fig. 1). If the slope of the ground water plane is uniform, the velocity along the ordinate y will equal $\frac{dy}{dx} \times M$, where M is the modulus of the water-bearing soil, or

$$v = \frac{dy}{dx} \times M.$$

The discharge per 1-ft. width of the section of ground water soil at right angles to the direction of flow will be

$$q = y\ M \frac{dy}{dx}$$

or

$$q\,dx = M\,y\,dy$$

Integrating both sides

$$q\,x = \tfrac{1}{2} M y^2 + c,$$

similarly for any other distance x_1 from o and ordinate y_1

$$q\ x_1 = \tfrac{1}{2}\ M\ y_1^2 + c$$

$$q = \frac{M}{2}\ \frac{y^2 - y_1^2}{x - x_1} = \frac{y - y_1}{x - x_1} \times \frac{y + y_1}{2} \times M$$

= tangent of the slope of the ground-water plane × mean ordinate × the modulus of the water-bearing soil. Or if s = tangent of the slope of the ground-water plane to the horizontal

$$q = M\,y\,s \text{ and } v = M\ s.$$

Flow of Ground Water Towards a Well.—The diagram, Fig.

2, due to Professor Schilter, illustrates the flow of ground-water towards a well, and the effect of the well on the lines of flow. The lines of ground-water flow are represented by equidistant parallel lines, and the lines of flow into the well by radial lines forming equal angles with each other. The arc A B is the boundary, down stream of the well, from which no flow of ground water enters the well. It has already been shown that the velocity of flow into a well from any distance x from the axis of the well due to the draught from the well for any head h is

$$v_1 = \frac{M\ h}{x \log_e \frac{D}{r}}$$

Where D is that distance from the axis of the well where the draught from the well shows no appreciable effect on the level of the ground-water plane, and r is the radius of the well. If s is the normal slope of the ground-water plane the velocity flow of the ground water towards the well may be represented by

$$v_2 = M\,S \cos\theta$$

∴ the total velocity or flow towards the well in any direction, or

$$v = v_1 + v_2 = \frac{M\,h}{x \log_e \frac{D}{r}} + M\,S \cos\theta$$

At B, vide Fig. 2, $\cos\theta = -1$ and $v = O$

$$\therefore\ x \text{ or } OB = \frac{h}{S \log_e \frac{D}{r}}$$

If $\theta = 90$ $\cos\theta = 0$ and $0A = D$.

Therefore where there is a flow of ground water towards a well, the tributary area of the well is a strip 2 D in width extending as far as the ground-water. Contours show a fall of the ground-water plane towards the well. If H is the depth of the water-bearing stratum, or depth to which the well has been sunk into the water-bearing stratum, the volume of ground water flowing towards the well will $= 2\,D\,H \times$ the velocity of flow of the ground water, or

$$Q = 2\,D\,H \times M\,s.$$

And this quantity is the maximum permanent yield of the well. If the draught from the well is in excess of this amount the well will in time fail. That is for a definite quantity of water to be drawn from a well for an indefinite period of time there must be an actual flow of ground water towards the well. The ground water in the tributary area may be replenished by:

(1) Rainfall on the exposed area which has penetrated to the ground water.

(2) Flood water of rivers over or alongside of the tributary area, which periodically replenishes the ground water.

(3) Surface flow of flood water which has been stored in reservoirs which feed the ground water by percolation.

(4) Percolation from irrigation from water drawn from a distant source.

Estimating Yield from Ground Water.—The actual estimation, for an extensive scheme of the yield from ground water is difficult. Rain is the chief source of ground water, but the catchment is often ill-defined. The only safe method is to actually ascertain the ground water contours over as large an area as possible. Five square miles at least. The hydrographical survey of this area is carried out by careful observations of the water levels of all wells in the area.

The observations should be made if possible before the wells are drawn on. A note should also be made of those wells at which there has been heavy pumping, or any considerable draught made on them. If old records are available the original water level in the well before being put to use will be most valuable. The fluctuations of water level during the seasons of the year should, if possible, be recorded. The geological sections of the wells should, if possible, be ascertained and recorded. The information obtained from existing wells should be augmented by sinking a series of boreholes at such places that with the observed water levels in the existing wells ground-water contours of the area under investigation can be drawn. The steepest slope, observed from the ground-water contours, will be that of the general direction of ground-water flow. The ground-water contours should show, if possible, the levels of the ground-water plane at the season of the year when the ground-water level is at its lowest. Where time is available the lag or time of replenishment of the wells after continuous and heavy rain should be noted.

Observations at Ootacamund, South India, showed that the range of ground water level for percolation wells from the end of the monsoon to the end of the dry weather period was 8 ft., the supply to the wells lagged two months after heavy rain. At the Kohlfrist the period by which the curve of output followed the curve of rainfall depended on the strata. The average of all observations was 12 months. In the case of humus it was only 3 hours. The velocity of flow of the ground-water can be ascertained from the slope of the ground-water plane, and from the size of grain of the water-bearing strata, as ascertained from the bore holes. The velocity may also be found by sinking a series of pipes at right angles to the general direction of flow, and one or more pipes a fixed distance of about 100 ft. above this line. A colored liquid or a solution of permanganate of potash is poured into the upper pipes, and water is drawn from the lower pipes till the water changes color; the time taken in the transit gives the velocity of the ground water. Or a solution of salts is poured into the upper pipes and water is drawn from the lower pipes until the salt is detected. The best method is to obtain the value of M from a yield test of a well sunk in the area to the full depth it is proposed to sink the permanent wells. Then if L be the length to be occupied by a line of wells at right angles to the direction of flow, the ground water supplying the wells will be:

$$Q = M\,H\,s\,(L + 2\,D)$$

Mutual Interference of Wells—The table below shows the mutual interference of a number of wells arranged in a row. The wells are assumed to be 6 in. diameter through the steining of which water passes as easily as through the soil, and the head pumped to is assumed as 10 ft.

Distance apart of the wells in feet.	Mutual interference, per cent
100	65.8
200	45.0
400	24.0
600	14.0
1,000	6.4

If the area is not periodically fed by floods from rivers or streams over the area, or adjacent to it, but depends for its supply on rainfall alone, the estimated yield ascertained by the ground flow should be compared with the amount of rain which is estimated to replenish the ground water. The Kohlfrist experiments give the average output of wells as 42 per cent of the average rainfall. The wells at Brooklyn, Long Island, U. S., yield 28.5 per cent of the rainfall. The sand dunes in Holland yield 30 per cent to 40 per cent of the rainfall.

Facing Concrete Buildings With Pottery.—In a recent lecture at Hanley Professor Beresford Pite discussed the possibilities of ceramic products in the clothing of reinforced concrete skeleton buildings. Unlike many architects who regard traditional practice as something quite sacred, Professor Pite would throw the conventions of the past to the winds in order to meet modern developments. While admitting the structural advantages of reinforced concrete, he is not an admirer of concrete as a material for exterior surfaces, and advocates the clothing of the structural skeleton with a "garment of permanent, effective, beautiful, ceramic color, unlimited in its variety and worth." The facing of such buildings with stone or brick is not only costly, but the materials themselves suffer considerably in appearance and otherwise from the atmosphere of large cities and towns. The proposal made by Professor Pite that pottery manufacturers should devote their energies to the production of architectural faience is one that will doubtless receive every support in the Five Towns. It should be remembered, however, that the initiative must come from the architectural profession, and we are sure that, if Professor Pite can induce his confrères to adopt the proposed method of facing reinforced concrete buildings, there will be no difficulty in obtaining ceramic products of suitable form and color.—The Times Engineering Supplement (London), February, 1921.

Treatment of Trade Waste by Activated Sludge Process

From Municipal Engineering and Sanitary Record, London, Nov. 25, 1920.

During the past two years careful experiments have been conducted at the Tunstall sewage works of the Corporation of Stoke-on-Trent in the application of the activated sludge system, and the results are given in an interesting and useful report issued by Mr. W. H. Makepeace, Borough Sewage Engineer. The sewage of this district is heavily charged with trade waste from the potteries, known as "slip," and the particular object of the experiments was to ascertain whether such sewage could be successfully treated by the activated sludge process. The Tunstall works were selected because the sewage was organically stronger and contained a much larger percentage of trades waste than at the other outfall works of the corporation.

The existing works were altered to adapt them to the activated sludge process and provided (a) a detritus tank, 9 ft. by 21 ft., having an average depth of 5 ft. 6 in. and containing 6,700 gal., (b) an aeration tank 75 ft. by 42 ft. 9 in. with semi-circular ends and average depth 7 ft. 9 in. (Its capacity was 156,875 gal., and the superficial water area 418 sq. yd.) (c) a sedimentation tank 25 ft. diameter and average depth of 13 ft. 10½ in., with capacity of 42,500 gal., and having a downward flow inlet and sludge scraper. A duplicate tank, doubling the capacity, was, however, put into commission at a later date.

The aerating tank was divided into ten bays by division walls with submerged portholes to permit the flow of the sewage through each bay in series. The floor of the inlet bay was formed on the ridge and furrow principle with diffusion plates across the full width of the bay at the bottom of each furrow. The other bays were divided lengthwise into three sections by baffle boards with a row of diffusers on the upstream side of each; the floors had a slight fall between each baffle in the direction of the flow. Air was supplied by an Ingersoll-Rand compressor having a capacity of 203 cu. ft. per minute when working at 10 lb. pressure, but the air pressure used was 4 lb.

Difficulty was at first experienced in getting the sludge built up to a satisfactory condition, and it was found that septic sludge was being formed at intervals throughout the aeration tank, particularly in front of each row of diffusers. There was also trouble in maintaining a regular and continuous supply of air, due partly to engine and compressor troubles. Investigation showed that some of the trouble was caused by an excess of "slip" in the aeration tank, and as this has a very high specific gravity—2.5—the air supply then available was not sufficient to keep it in circulation, and it settled in places to a depth of 3 ft. Many of the diffusers were found to be choked, and trouble was caused by a short-circuiting through several small openings which had been left in the division walls at the time they were built in order to facilitate emptying when necessary. The amount of "slip" was reduced by passing the detritus tank effluent through an additional grit chamber; the holes in the division walls were blocked up, the diffusers cleaned and the compressor speed slightly increased. From the time these alterations were completed the results steadily improved until the necessary quantity and right quality of sludge was built up. This occurred in July, 1919, and since that date a most satisfactory effluent has been consistently produced. During the first two months of these initial experiments the plant was worked on the continuous flow system, but subsequently the fill and draw method was adopted.

After a satisfactory effluent had been obtained the tanks were worked on the continuous flow method at the rate of 120,000 gal. per 24 hours, which was increased after a few weeks to the rate of 300,000 gallons per day and an effluent of consistent good quality was obtained. The remarkable feature of this was the high nitrate figure produced and the thoroughly stable character of the effluent has always been satisfactory; the reduction of the bacteria content amounts to 98 per cent, and the dissolved oxygen test shows 0.33 parts per 100,000 compared with the Royal Commission limit of 2 parts. Careful observation was made of the sludge returned from the settlement tank to the re-aeration tank, and it was found, after three hours' settlement, to be 70 per cent of the total volume returned. The average analysis of the activated sludge in parts per 100, or as a percentage, was: Mineral matter, 49.2; organic matter, 50.8; nitrogen, 4.5; grease, 2.75.

Experiments were made with percentages of sludge in the aeration tank varying from 25 to 45 to ascertain whether it was practicable to carry a reserve of activated sludge in a tank normally dealing with a dry weather flow so as to provide the additional sludge necessary to comply with the Ministry of Health's requirements for treating the varying rate of flow of sewage, viz., from one to three times, in stand-by tanks. It was found that an excess quantity of sludge could be successfully maintained by a dry weather flow, and that if stand-by tanks were provided and mechanical means arranged for rapidly discharging the surplus sludge from the dry weather flow tanks, varying rates up to three times the dry weather flow can be successfully treated.

Throughout the experiments the flow dealt with was not constant, but varied exactly in proportion to the flow from the sewers. Good results were obtained with settlement tanks of half the capacity of the aerating tanks, but Mr. Makepeace is of opinion that they would have been better with pyramidical bottoms. The activated sludge showed an increase of nitrogen content of 346 per cent over ordinary sludge, which brings its utilization for fertilizing purposes within the range of a commercial proposition.

The most successful method of sludge treatment was found to be evaporation by utilizing waste heat from an oil engine exhaust pipe. The plant has intentionally been satisfactorily subjected to all sorts of abuse which it would be likely to meet in everyday practice. It was found that sewage could be run through the tanks for three or four hours while the air supply was discontinued, without serious effect on the effluent. Again, the compressor and the inflowing sewage was stopped for periods of from three to ten hours in twenty-four, and the efficiency was unimpaired when the flow was re-started. The quantity of air was varied from 1.108 to .624 cu. ft. per gallon, without any effect except to reduce the velocity through the aeration tank from about 2.5 ft. per second to 1.5 ft. Below this rate settlement on the bottom commenced.

Mr. Makepeace has formulated the conclusions he has reached as a result of the experiments in a very concise manner. He considers that the system is reliable when once established, and is not likely to be interferred with by the trade wastes of the potteries. The system is considerably less costly to construct than ordinary bacterial methods, and its maintenance would be less than that of their existing plants. It can often be applied without a pumping scheme. The works can be controlled by a much smaller but more skilled staff. There is no aerial nuisance under the worst conditions, while the resultant sludge is inoffensive and possesses higher fertilizing value than the sludge from existing plants. An area of bacterial beds should be constructed or suitable land provided for use in case of a possible breakdown of the activated sludge plants.

Mr. Makepeace estimates that a complete plant, partly bacterial and partly activated sludge, for a population of 50,000 with a dry weather flow of 1½ million gallons would cost £85,000 as against £125,000 for a plant on present-day bacterial lines. This includes for dealing in times of storm with three times the dry weather flow as sewage and three to six times as storm water. The maintenance charges (excluding capital charges) are estimated at £4,372 compared with £6,800 for a plant wholly bacterial.

The scheme Mr. Makepeace recommends for a new installation includes: Three detritus tanks, total capacity 1/25 dry weather flow; two sedimentation tanks, total capacity 1/3 dry weather flow; two aeration tanks (subdivided), total capacity 2/3 dry weather flow; two settlement tanks (pyramidical bottoms), total capacity 1/3 dry weather flow; bacteria beds of cubic capacity equal to 1/3 dry weather flow on basis of 70 gal. per cubic yard; two sludge storage tanks for dewatering sludge from settlement tanks before drying, total capacity 1/130 dry weather flow; and sludge beds based on 1 sq. yd. per 16 persons.

Design Features of the Warrington Reinforced Concrete Bridge

From Engineering, London, Feb. 11, 1921.

The advent of the war in 1914 prevented a number of important engineering works in this country receiving the attention they merited from engineers, or that they otherwise would probably have obtained. A case in point is the reconstruction of the Warrington Bridge. This bridge has a clear span of 134 ft. and is 80 ft. wide, being similar in the latter respect to Westminster Bridge. Designs were invited in September, 1909, for a single-span structure, the design of The Considère Construction Co. of Westminster, being chosen. This design consisted of a reinforced concrete structure having eight elastic arched ribs spanning from piled abutments, and supporting the deck by means of short columns spaced at suitable intervals.

The outstanding difficulty in designing such bridges is the impossibility of accurately determining the stresses due to the shrinkage of the concrete and the initial settlement during construction. A very ingenious solution of this difficulty, proposed by M. A. Considère, was adopted. It consists of introducing temporary hinges at the springings and crown of each arched rib. The bridge is then free to settle under its own weight, without any possible overstrain of the ribs; moreover, the design is thus considerably simplified, since for all the dead loads (which of course contribute principally to settlement) the static solution of the three-pinned arch can be employed, and the thrust at the abutments accurately and easily determined. The temporary hinges were formed by reducing the sectional area of the concrete ribs to 360 sq. in., and heavily reinforcing this small area with short longitudinal rods, enclosed by closely pitched steel spirals. It is calculated that the concrete enclosed in these spirals was subjected during construction to an actual compressive stress of over 1,500 lb. per square inch. This stress, of course, could not have been permitted but for the great increase in resistance afforded by the manner in which it was reinforced.

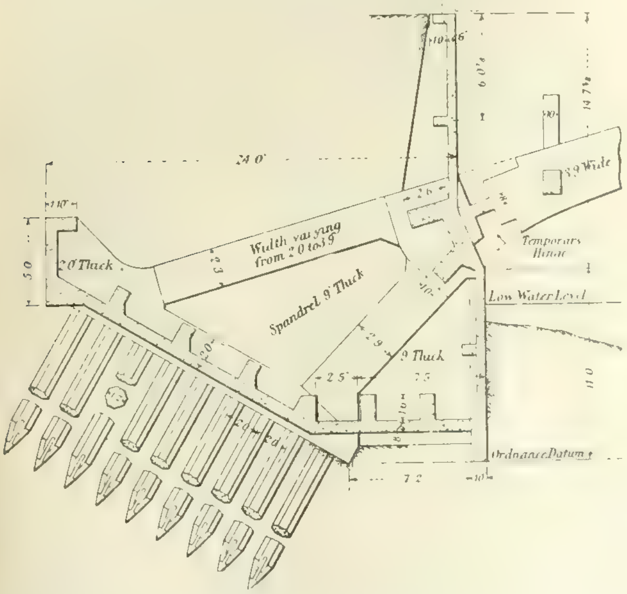


Fig. 1—Detail of Abutment.

It is evident that, with the very abrupt change of section at the temporary hinges, a great concentration of stress takes place in the ribs adjacent to these reduced areas. This is provided for by placing a suitable number of shearing rods across the ribs on each side of all the hinges.

After the construction of the bridge, that is, when the whole of the dead load had been placed upon the structure, the hinges were carefully filled in with concrete, and the normal section of the ribs made good.

The manner in which these temporary hinges were introduced will be clear from the illustrations. Fig. 1 is a section of one abutment which shows the hinge introduced at the springing. For the sake of clearness the reinforcement is left out in this drawing. Figs. 2 and 3 show details of the reinforcement at the center hinge. The main reinforcement of the arch ribs consists of groups of bars surrounded with coils, disposed towards the upper and lower sides of each rib. The special reinforcement alluded to above provided at the hinges is similar and follows the arrangement shown in Figs. 2 and 3 which actually depict a center hinge.

For the heavy rolling and superloads specified, a graphical solution of the elastic theory was used, and influence line curves set up for seven equally-spaced sections of the ribs. From these the greatest moments obtainable, under any combination of the loads specified, were found for each section. To these were added the moments due to variations of temperature (± 30° F.) and an envelope of maximum moments then plotted.

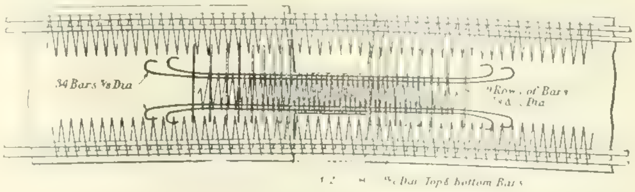


Fig. 2—Detail of Reinforcement at Center Hinge.

The reinforcement for the ribs was calculated in accordance with the method of M. Considère, and the concrete spiralled to take the very high compression. The longitudinal reinforcement is symmetrically arranged, there being 15 rods each at the intrados and extrados throughout the length of the ribs, with seven additional rods added to the top and bottom of each of the ribs at the springings. There are seven continuous steel spirals, 8 in. in diameter, at the top and bottom of each rib, and also transverse reinforcement, in the form of small stirrups, and lateral ties at 9-in. spacing.

The thrust from the ribs at the supports was very great, amounting to over 350 tons for each of the intermediate ribs, and it was therefore necessary to provide adequate abutments. These were arranged by placing bracketted counterforts opposite each of the ribs which distribute the loads from the latter, to an inclined foundation slab resting on virgin ground, and also onto reinforced concrete piles driven into hard clay, and arranged in rows of nine, in line with each of the ribs. This arrangement will be clear from Fig. 1. The piles were driven to an inclination approximating as closely as practicable to the direction of the dead load thrust, combined with the weight of the earth filling above the foundation slab, the latter amounting to 266 tons per rib.

With this arrangement, there remained an unbalanced thrust tending to cause the whole abutment to slide outwards. This force was provided for by turning up the outer edge of the foundation slab, and supporting this by horizontal beams bearing on the counterforts. Any movement of the abutments was thus prevented by the resistance offered by the earth at the back of the inclined and vertical faces of the latter slab. The foundation slabs are situated 9 ft. below low water-level, and it was therefore necessary to construct them with cofferdams. For these steel sheet piling was utilized.

The bridge was constructed in two portions, sufficient width being erected on the down-stream side of the old bridge to allow traffic to pass over. When this portion was in use, the old bridge was pulled down, and the new bridge completed. Training walls were built on both sides of the river, and by this means the flow of the river was regulated, and silting successfully prevented. These walls were composed of a thin vertical wall with a horizontal base slab, and supported by counterforts, the whole resting upon reinforced concrete sheet piles, and being tied back at intervals by means of reinforced concrete ties and anchor slabs.

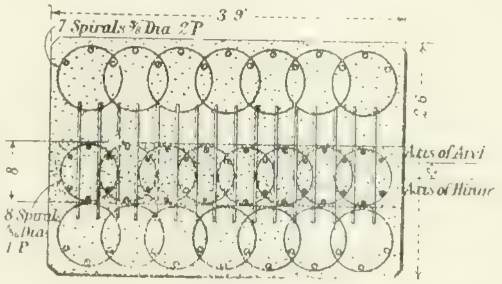


Fig. 3—Detail of Reinforcement at Center Hinge.

One of the difficulties met with during construction was in connection with the centering. In order to allow navigation to continue, a clear waterway of 30 ft. had to be left in the center, and the head-room could not be reduced by more than 6 in. To overcome this difficulty, composite girders of 50-ft. span, of wood and steel, were provided, and from these the whole of the centering for the reinforced concrete work was slung.

An allowance of 4 in. was made in the setting-out of the timber centering, for deflection of the ribs during construction, and it is interesting to note that the actual settlement at the crown, one month after the centering was struck, was 3 in., and afer 18 months of traffic, the total settlement has increased to 4 in., which agreed with the amount provided for.

As explained above, each of the ribs was provided with temporary flexural hinges, and designed as a three-pinned arch for the whole of the permanent dead load. It was therefore necessary for this condition to obtain after the placing of the concrete deck slab and paving. This was accomplished by omitting a transverse strip of the concrete slab across the whole width of the bridge, directly over the crown hinges. In order to further facilitate the free movement of the ribs under the above condition, the vertical columns resting upon the ribs and supporting the deck beams, were made as thin as possible in the direction of the span of the bridge. In this way the minimum resistance was offered to any relative movement longitudinally between the deck and the ribs.

Before the temporary hinges were finally concreted in, the timber centering was lowered, and in order that this should be both uniform and gradual steel screws were arranged under the supports. With the object of eliminating, as far as possible, any initial stress due to shrinkage, the concrete in the ribs was placed in sections, and key spaces left over the supports of the centering. These key spaces were filled in after all the sections had been completed. The total quantities of materials used in the construction were as follows: Steel, 242 tons; concrete, 2,400 cu. yd.

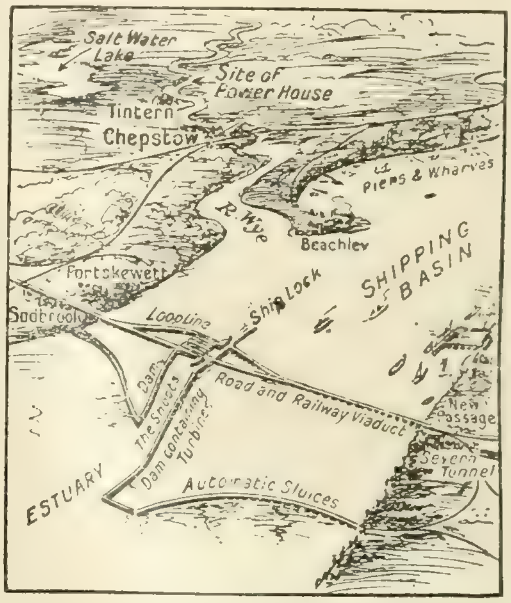
When the bridge was completed, five tramcars, weighing 12 tons each, and two steam-rollers, one weighing 20 tons and the other 15 tons, were crowded as closely as possible onto the center of the bridge. Under this total dead load of 95 tons, the deflection at the center of the arch was about 1/32 in. After this, a 20-ton steam-roller, followed closely by five loaded tramcars, were run as fast as possible over the bridge. Under this rolling load of 80 tons the deflection was about 1/64 in., and the total movement due to vibration 1/32 in.

A 50-year-old Example of "Accidental" Reinforcement of Concrete.—In the course of legal proceedings at a watering place on the South Coast some interesting evidence was given last month with regard to the condition and behavior of wrought iron joists embedded in concrete nearly half a century ago. The structure in question consists of a framework of small wrought iron joists filled in and covered over by concrete, originally forming a monolithic slab about 12 in. thick. As the work was designed and executed at a time when reinforced concrete, in the modern acceptation of the term, was practically unknown, the natural supposition is that the architect responsible for the design relied upon the ironwork for the support of all loads and regarded the concrete merely as a filling and covering material. The upper surface of the construction forms part of a marine parade for pedestrian traffic and the lower surface provides roofing for a series of underground halls and chambers, used for purposes which do not concern the present note. An essential point, however, is that the municipal authorities were advised that the roof generally was a dangerous structure and brought forward convincing evidence as to the justice of this opinion. The testimony of two well-known authorities with regard to the wrought iron and concrete construction was to the effect that the original factor of safety had virtually disappeared owing to deterioration of the exposed lower flanges of the iron joists and the formation of cracks in the concrete. In consequence of these defects, it appeared that the ironwork was no longer capable of supporting the deadweight of the materials and the existing superimposed loading, and that failure had been averted in consequence of the fact that, quite unintentionally on the part of the designer, the upper flanges and webs of the joists (these parts being in a state of fair preservation owing to the protection by the surrounding concrete) had been acting with the monolithic slab in such a way as to constitute an accidental, but not particularly efficient, example of reinforced concrete construction. This unpremeditated anticipation of modern practice is certainly interesting.—The Times Engineering Supplement (London), November, 1920.

The Severn Tidal Power Development

From The Times Engineering Supplement, London, December, 1920.

The British Ministry of Transport has announced a scheme which it has prepared for the utilization of the tidal power of the Severn. Briefly, the proposal is to build a dam across the river at a point a little below the confluence of the Wye, where the width is about 2½ miles. Part of this dam would contain automatic sluices opening to admit water to the upper reaches on the rising tide, but closing to impound it on the ebb; and another part water turbines and generating plant. The dam would be divided into two portions by a deep-water channel and a ship lock, and with the latter would be combined a viaduct carrying railway lines and a road, which would provide relief for the congestion of the traffic passing into and out of South Wales.



The Severn Scheme for Utilization of Tidal Power.

With this arrangement power would be obtained only during a portion of the tidal cycle; owing to the ebb tide in the Severn occupying a longer period than the flood tide, a working period of about seven hours is thought possible. During this period the head of water available would be constantly varying, from about 5 ft., at which the turbines would begin to work, to a maximum at spring tides of 30 ft. The vertical-axis mixed-flow turbines it is proposed to employ must, for efficiency, run at a different speed for each head, and therefore the dynamos attached to them must be adapted to suit their varying speeds. To meet this condition vertical-axis direct-current dynamos are proposed, separately excited with shunt characteristic; and either automatically or through an operator their excitation and load currents would be so controlled that the resisting torque offered by them would prevent the turbines from rotating at a speed greater than the theoretically correct speed for maximum output at each head. The turbines would rotate at speeds between about 40 and 80 r.p.m., and the dynamos, driven through helical gearing at between 300 and 500 r.p.m., would generate at a constant voltage of 525, the average output of each being about 1,300 k.w.

Energy from the tidal generators would be transmitted direct to industry, but at such times as they were producing more than could be absorbed, the residue would be transmitted about 10 miles and used to pump water up into a high-level reservoir situated above Tintern Abbey. This water would then be used to drive turbines in a second generating station, which would be able to supply at periods when the tidal generators were idle. For conveying this water to the high-level reservoir a tunnel 40 ft. in diameter and over a mile long would be cut through solid rock. The motors for driving the pumps would have a speed of about 375 r.p.m. working at 2,200 volts, and each having an output of about 13,000 kw. To save the cost of installing two sets of machinery at the storage reservoir generating station, it is proposed to combine in one machine the motor for pumping and the generator, which would be driven by a turbine at times when the reservoir was giving out power. While the amount of energy to be derived from the tides in the Severn is put on the average, week in and week out, at "about half-a-million horse-power for a ten-hour day," the idea is to install machinery at the storage reservoir station to give a maximum or peak output of approximately one million horse-power.

The direct current generated at 525 volts by the tidal turbines would be converted into alternating current at 300 volts and then stepped up by static transformers to 60,000 volts for transmission. Four principal outlets for the power are suggested. The first is the immediate neighborhood of the Severn, for the industries which would be fostered by cheap power on the banks of the shipping basin formed above the dam. The second is the industrial area of South Wales, all of which lies within 50 miles of the barrage. The third is the English Midlands (Birmingham being about 70 miles distant, and Stoke-on-Trent, about 100 miles), where considerable difficulty is anticipated in setting up large steam power stations on account of the lack of condensing water. The fourth is the Thames Valley and London (115 miles), to which it is thought transmission at 120,000 volts may be possible.

Since the storage reservoir power house is capable of producing peak load output at short notice, it is suggested that the appropriate use for the electrical energy from the Severn is to take up the peak load in industrial areas. That is, the Severn scheme can be made to work largely in conjunction with steam generating stations in such a way as to enable them to work with a load factor of from 70 to 80 per cent, instead of 20 to 50 per cent, as at present.

A New Method of Sand Pumping

By R. H. SQUIRE.

From Water and Water Engineering, London, Feb. 21, 1921.

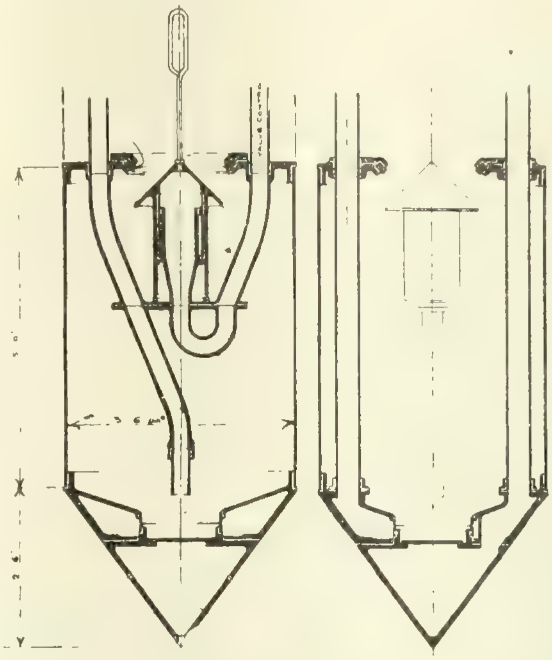
The general idea is that by passing water from ordinary pumps across the bottom of a sealed chamber containing sand, a certain amount of sand is picked up, and the mixture so obtained can be led by a pipe line wherever desired. The diagram shows two sections through the apparatus. This consists of a cylindrical vessel sealed at the bottom, and with a large opening in the top capable of being closed by a valve. The valve is hydraulically operated through the pipe marked "valve control." There are three other pipes passing into the chamber through the top cover. One of these is the delivery pipe. The second brings the water from the pumps into the small annular chamber at the bottom, from whence it escapes into the main chamber through a small opening left between two brass rings. The particular design shown in this diagram was intended to be sunk into the sand in the river bed and the fourth pipe, which has nothing to do with the actual working, is provided for this purpose. This leads into a nosepiece. On pumping a sufficient supply of water through this pipe, the sand under the nose is washed away by the water escaping through the small holes shown, and the whole thing sinks bodily.

Since the function of the apparatus is to supply the sand to the mixture and control the percentage of solids delivered, I have called it a "mixer."

Now, to understand the way in which this mixer works, it is necessary to remember that there is a solid mass of wet sand above the mixer. If the valve is down, as shown in the diagram, the sand finds its way into the mixer by gravity. Upon water being supplied to the two pipes marked "feed" and "valve control," the valve lifts and seals the mixer; the only escape for the feed water is now through the delivery pipe, but in crossing the space between the outlet from the annular chamber to the mouth of the delivery pipe it picks up a certain amount of sand. The actual amount depends on several variables, and can be regulated between wide limits. Once adjusted, however, to any particular percentage, the variation is small, and if the sand were perfectly uniform, would probably disappear altogether. As the sand leaves the mixer, it is replaced in the chamber by part of the water from the pumps.

If the water supply be now shut off, the valve will drop, and the mixer again fill with sand, the water in the mixer escaping up through the sand above. As soon as the filling process is complete, we are ready to repeat the cycle of operations. Since this alternate filling and emptying involves an intermittent delivery, which is not admissible in practice, it is necessary to have at least two units, leading the delivery pipes onto a common main, and isolating each unit by a non-return valve on the delivery between the mixer and the common main.

The percentage of solids delivered, and the supply of water remaining constant, it can easily be seen that the time required to empty the sand from the mixer is also constant. Again, the time required for filling is constant, and these times can be adjusted so that they are equal in a two-unit plant, or bear any required proportion to each other in the case of a plant having three or more units. It is therefore an easy matter to arrange a distribution valve, driven from the pump, to supply the water to each mixer in rotation for the period necessary. The pumps can be of any desired type, but either a duplex steam pump or a three-plunger pump, electrically driven, is to be preferred. The system has been patented by the author under Indian Pat. No. 4060 of 1918 and English Pat. No. 1572 of 1919.



Sectional Views of Mixer.

Friction Losses from Mixture of Sand and Water.—As an example of the friction losses which occur when a mixture of sand and water flows through a pipe a series of experiments carried out with a 40 per cent mixture may be given. The mixture was pumped through a 3-in. pipe line of approximately 500 ft. in length. A pressure gage on the mixer enabled the pressure head to be accurately determined, and the difference of level of the two ends of the pipe line was carefully taken to determine the static head. The velocity of flow was measured by filling steel drums of 8.4 cu. ft. capacity and the time taken noted on a stop watch. A wrought iron bend was loosely screwed onto the discharge end of the pipe line and by swinging the bend across, the flow of mixture was easily diverted into one of the drums just long enough to fill it without overflowing. The percentage of solids was checked on each test by measuring the depth of sand and depth of water in the drums. At anything below the critical velocity part of the sand commences to settle out, and instead of being carried in suspension is dragged along the bottom of the pipe at a lower velocity, which results in the higher resistance set up. The equilibrium of the system is now unstable and unless there is a reserve of power available somewhere, flow will rapidly cease and the pipe choke. There was no reserve available in Blue's experiments and hence a very small variation caused the launder to choke.

By considering the two results together and bearing in mind the conditions of the two sets of experiments we can now get a very good idea of what actually happens. Let us suppose that we have a gravity system with a bore pipe of 100 ft. vertical, and with 900 ft. of pipe to the working face dipping at an average of 1 in 15. If the borehole is kept full this will give an average gradient of 16.0 per cent. This corresponds nearly to a safe mixture of 40 per cent solids, and the velocity of flow would be 11.5 ft. per second. This, on a 3-in. pipe, gives a total discharge of practically 34 cu. ft. per minute. Let us suppose, however, that the rate of supply of mixture to the hopper on the bore pipe is only 25 cu. ft. per minute. Now the discharge rate being greater than the rate of supply it follows that the head of mixture in the bore will continue to fall until the rates of supply and discharge are equal, i.e., in the case we are considering until the discharge velocity is about 8.5 ft. per second. We are now not very far above the critical velocity and the case is the same as when a dangerously high proportion of solids is being used for the head per cent available. With this narrow margin a very small increase in the percentage of solids or a decrease in the rate of supply will suffice to bring the rate of flow down to the critical velocity. If this occurs, the sand commences to settle out and the resistance rises rapidly with a further drop in the velocity of discharge. The discharge rate now being below the supply rate the head in the bore begins to mount up and when this rise of head overtakes the increasing resistance, we get a rush of discharge as the velocity runs up to the point on the curve above the critical point, which corresponds to the head again available in the bore. We thus get an intermittent or hunting effect in the discharge, which is by no means an uncommon feature. Moreover, if the total depth of the bore is not sufficient to allow the increasing head to catch up and overtake the increasing resistance then we get a choked system.

This hunting effect is a very important indication that one or other of three things is wrong, and it should on no account be allowed to continue. These are either:

(1) The percentage of solids in the mixture is dangerously high;

(2) The rate of supply to the bore is too low; or

(3) If it is not desired, or not possible, to increase the rate of supply, the discharge pipe is too large.

Wear of Pipes.—An important point which is closely connected with the friction in pipes, is the wear on pipes. The writer believes that this is not so serious when sand is the material to be flushed through the pipe as is usually supposed.

In the case of the Saarbrucken collieries it is stated that steel pipes 5/16 in. thick had to be turned after 43,200 cu. m. of sand had been passed through them. This is about 76,000 tons and would correspond to only six months work for a pipe line passing 50 tons per hour. Neither the velocity of the flow nor actual amount of wear is stated, however. At Ballapur Colliery it was stated in Mr. Davis' paper that the cast iron pipes had scored 1/16 in. deep, with 34,000 tons of sand.

On the other hand the writer has seen some pipes belonging to a small dredger of the Calcutta Port Commissioners which, it was stated, had passed something considerably in excess of 75,000 tons of clean sand on one not very extensive reclamation job. The engineer in charge of the dredger did not consider that there was any wear on the straight pipes, and certainly there was not much.

It would appear that the crux of this matter is the velocity of flow. If this is above the critical velocity the wear is small, while below the critical velocity the wear becomes heavy, as is shown by the friction resistance.

The Saarbrucken results indicate that the velocity was low, for the wear was evidently along the lower side of the pipe. With a high velocity the sand is so evenly carried in suspension that any wear that takes place must be fairly equally distributed. At Ballapur the velocity of flow is given as 24.3 ft. per second now—quite high enough to give even wear—but originally it was probably rather low and the bulk of the wear may have occurred before the re-arrangement.

Roman Concrete in Lincoln, England.—During the recent visit of the Institution of Mechanical Engineers to Lincoln, Colonel Mansel Sympson delivered a lecture on "Roman Lincoln" giving interesting details concerning the ancient city walls and the endurance of ancient concrete in those structures. It appears, states the Times Engineering Supplement of November, 1920, that the walls were originally built of mass concrete faced with masonry, a very general practice of Roman engineers and largely followed to this day. At present, as stated by Colonel Sympson, a large fragment of the wall on the eastern side of the city is still in existence, although the stone facing has gone from both sides, leaving only the core, which consists of mass concrete, embedding pebbles and small stones, with a few courses of stone laid edgewise. Near the old Eastern Gate there was found in 1890 a strong concrete platform on which ballistæ, or large catapults, are believed to have been fixed, this platform fulfilling a purpose very much akin to that of the concrete gun emplacements of which so much was heard during the war.

New System of Forms for Concrete House Construction

From Concrete and Constructional Engineering, London.

One of the results of the increased cost of building has been the reduction to an absolute minimum in British State-aided housing schemes of all artistic adornment and architectural features which are designed solely to add to the charm of the houses, and do not fulfill some utilitarian purpose. With 4 and 5-room houses averaging from $4,400 to $4,900 each, this, although much to be regretted, can hardly be taken exception to; but, as has been frequently pointed out, concrete lends itself particularly well to artistic treatment without any extra expense whatever being incurred. This result is obtained in a variety of ways, some rather complicated and some extremely simple.

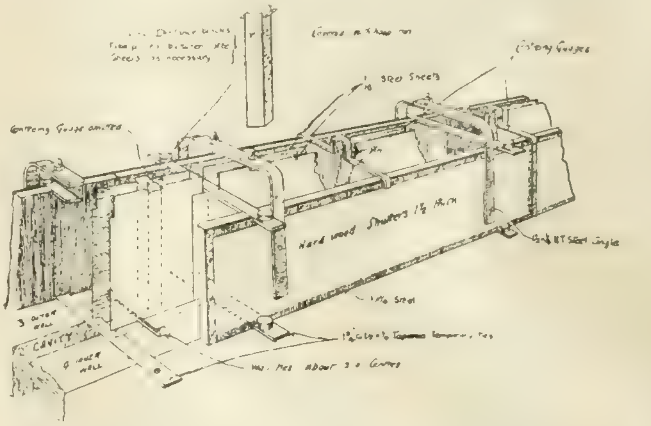


Fig. 1—Method of Constructing Cavity Walls With Spade Forms and Special Removable Core.

A very simple and ingenious method is used in connection with the "Spade" system of forms, invented and patented by Mr. A. L. Woodward, of Ardmay Hotel, Surbiton, England. As will be seen in Fig. 1, the forms consist of pieces of hardwood held together and kept at the required distance apart by steel angles. When a cavity wall is being built, a core of two sheets of steel is inserted, and held in position by distance blocks and a centering gage. The forms are kept true as the succeeding courses are being built by temporary ties being placed across the last completed course, and removed when the shuttering is removed. Wall ties are built in at each course as the work proceeds. Each course is built its entire length at one operation, so that there

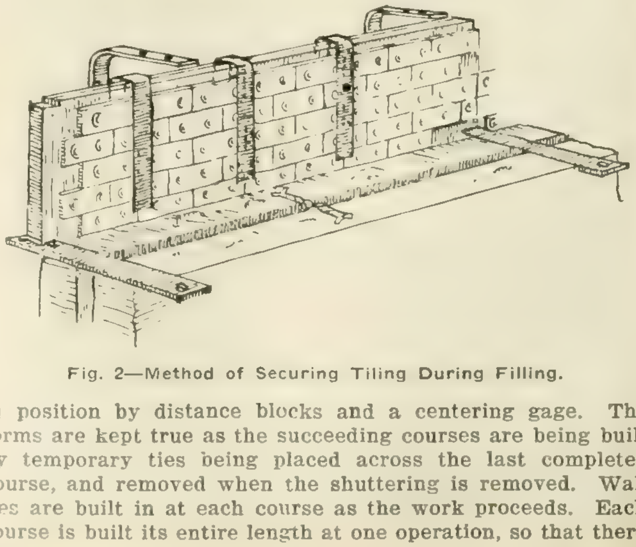


Fig. 2—Method of Securing Tiling During Filling.

are no vertical joints. The forms are made in four lengths, between 4 ft. 6 in. and 3 ft. 2½ in., and combinations of sets of these forms will give several hundred different dimensions between 3 ft. 2½ in. and 50 ft., so that there is no difficulty in working to different plans.

Perhaps the most interesting feature of the system is the method adopted for obtaining various exterior finishes. Fig. 2 shows the method of obtaining a tiled surface without any labor being required beyond that necessary to build the wall. The tiles are placed inside the forms and held in position by strips of hoop iron while the concrete is being filled in; when the forms are removed they, of course, adhere to the wall. In a piece of walling which we had an opportunity of inspecting tiles had been built in this manner as a surround for a fireplace, and appeared to be quite satisfactory. On another section of walling a mould had been used in the forms which gave the appearance of ordinary brickwork, properly pointed, which had not been touched after the removal of the shuttering. To give the appearance of roughcast a piece of ordinary matting is used inside the shutter. By these methods excellent reproductions can be obtained of stonework, and even weather-boarding, without incurring any extra expense or labor beyond placing the mould in position inside the forms. This system eliminates all supporting piers, posts and struts, whether permanent or of a temporary nature, and the forms can be erected to the required dimensions without the aid of measuring instruments or gages. The system will shortly be used by two public bodies in connection with housing schemes.

The Rusting of Steel Containing Copper

From Engineering, London, Feb. 18, 1921.

It is generally believed, and this belief was confirmed by the rust tests of the American Sheet & Tin Plate Co., of Pittsburgh, in 1913, that iron containing copper, in amounts of small fractions of 1 per cent, is less liable to rust than iron free from copper, though that might seem to contradict the assumption that iron should be corroded electrolytically more easily in the presence than in the absence of a metal like copper. To investigate this problem further some comprehensive tests extending over six years were started in 1913 by Professor O. Bauer of the Materialprüfungsamt, at Gross Lichterfelde, near Berlin, on behalf of the German ironmasters. The material was obtained from three works, two in the Rhenish district, one in Silesia; all three works sent Thomas and Siemens and other steels in large sheets to be tested both with their skins on and after the skins had been removed. All the steels were fairly pure; Carbon about 0.1 per cent, manganese about 0.5 per cent, phosphorous and also sulphur up to 0.09 per cent, nickel up to 0.2 per cent, chromium 0.04 maximum; the copper had purposely been added in percentages up to 0.35. The weighed sheets were exposed to various atmospheres and liquids for varying periods, and the rust was then removed for quantitative determination by an unusually thorough method. The sheets were brushed and then placed in an iron tank, in which they were heated to boiling temperature for 2½ hours in 8 per cent solution of caustic soda, granulated zinc having been spread on the upper surface of each sheet; the sheets were then turned, the zinc was applied to the other surface, and the heating was renewed. All rust could then easily be brushed off if still adhering; the treatment did not attack the clean metal. A full account of these tests is given in Stahl und Eisen, of Jan. 13 and 20 last.

The specimens, sheets 1 m. by 0.5 m. were exposed for over four years on the roof of the Amt in good country air, being suspended from wooden frames to which they were fixed by iron nails. Any influence of the copper content on the rapidity of rusting was not noticeable. In the salt spray of the island of Sylt, in the North Sea, the rusting was more marked, but again the copper made no difference; in the very impure air of the Hoesch iron works near Dortmund, however, a protective influence of the copper was perceptible. In all the cases the nickel in the steel also seemed to prevent rusting. Buried in the sand dunes of Sylt so as to be exposed both to the sea water and to air the sheets suffered more than in impure air, but the influence of copper was uncertain. Exposed in the sea water alone the rusting was also strong, and again the action of the copper was doubtful. Sheets were then buried in the ground of the Hoesch iron works, the full size sheets being, as in the other buried tests, placed edgeways in the ground. The ground in this instance consisted of coarse-grained slags containing about 31 per cent of silica, 42 per cent of lime, 13 per cent of alumina and only 0.13 per cent of SO_3; this last percentage is interesting with regard to other tests to be mentioned. In this slag sand the corrosion of the steel was not more marked certainly than in the sand dunes of the North Sea, but again the influence of the copper was not clear; the copper seemed to protect the Siemens steel, and to hasten the corrosion of the other steels. Summing up these various tests—all made on the metal with its skin on—it would appear that in the presence of relatively high percentages of carbon dioxide and of sulphur dioxide a slight percentage of copper—and of nickel as well, it should be noted—seemed to retard the rusting of steel.

The other experiments were made with smaller plates, about 80 mm. by 47 mm. by 2 mm. generally, which had been cut out of the larger plates and had been cleaned and ground bright by the aid of emery. These smaller specimens were strung on wires of mild steel for the atmospheric tests. In the clean country air the copper possibly afforded some protection against rusting, but the influence was weak at the best. In distilled water the copper made no difference; in the supply water of the Amt and in the salt water of the North Sea copper was equally ineffective, though the supply water contained some carbon dioxide and, for that reason probably, corroded the steel more than the sea water. In special tests made in distilled water impregnated with CO_2, as well as in diluted solutions of common salt (1 per cent), with or without CO_2, the copper seemed to have a retarding influence, and that was confirmed by measurements of the potential differences. But the potential differences observed were very small, and they vanished altogether in the course of a few days; in any case they seemed to remain effective only in fairly-saturated solutions of carbon dioxide.

Finally, electrolytic tests were conducted with the specimens suspended in diluted sulphuric acid, on the assumption that the protective influence of copper noticed in the atmosphere of the Hoesch iron works might be connected with the vapors of SO_2 in that atmosphere. It was indeed found that steel suffers in diluted sulphuric acid less corrosion when it contains a small percentage of copper than in the absence of copper. This protective influence was particularly marked in the case of the steels relatively high in phosphorus; the copper seemed to counteract the evil effects of the phosphorus. Even in these cases the anticorrosive effect of copper on steel was not strong, however, and it does not appear that the addition of copper to steel for the purpose of preventing corrosion would generally be advisable.

Steel for Reinforcement.—A paper read to the Concrete Institute by Mr. H. Kempson Dyson describes a series of tests undertaken by a sub-committee of the institute with the object of obtaining data as a basis for the formulation of permissible working stresses for steels of higher tensile strength than that required by the British standard specification for structional steel. The qualities of special steel on the market suitable for the reinforcement of concrete were found to belong to three classes—(1) medium carbon steel; (2) cold worked steel (such as twisted bars); and (3) drawn steel wire. The tests were made on a number of beams and slabs reinforced with these kinds of steel, and were conducted under the supervision of the committee at the Manchester College of Technology. From the records obtained it may be concluded that, with the usual safety factor of 4, it would be right to design (as compared with the working stress of 16,000 lb. per square inch for mild steel) for working stresses of 22,000 lb. per square inch for medium carbon steel, 21,500 lb. per square inch for cold worked steel, and 25,000 lb. per square inch for drawn steel wire of the qualities employed in the tests. Engineers and makers who are interested in the application of such steels have generally been content with a working stress of 20,000 lb. per square inch. Therefore their contention is more than supported by the results of the tests mentioned.—The Times Engineering Supplement (London), February, 1921.

Walker-Weston System of Reinforcement for Concrete Roads

From Engineering, London, Feb. [illegible] 1921

This system provides a reinforced frame which can be made close to the site, and which by reason of its diagonals is a very stiff structure. The frame itself is shown in plan, in Fig. 1. We may also state that the Port of London Authority has laid down considerable areas of this type of road at its docks. Also it is being used for reinforcing heavy traffic roads at the Belfast Shipyards of Messrs. Harland and Wolff. The whole reinforcement is built up of three classes of bars. Of these one class consists of a zig-zag bar shown as Section A B in Fig. 1. The second of a type of loop bar, while the third consists of plain straight bars. The zig-zag and loop bars can be prepared at the site, so that no complicated shaped bars have to be considered in transport.

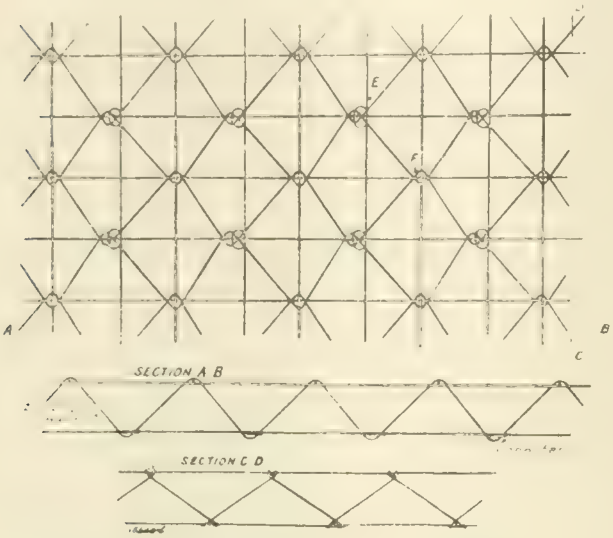


Fig. 1—Plan and Sections of Reinforcement.

The zig-zag bars are prepared on a bench set with pegs, round which the bars are bent, and the pegs can be set any desired distance apart so that the depth of the zig-zag can be varied, the pitch always remaining standard. The zig-zag bars are usually of from ⅛ in. to 3/16 in. diameter, this material being as a rule delivered in coils. These coils are stretched by winches at the site, and lengths of 40 ft. or so cut and bent by hand on the bench, using two short lengths of steel tube threaded on the bar for this purpose.

The loop bars are also prepared on a single bench on which are pegs at standard intervals. These bars are manipulated by a claw tool which enables them to be bent very expeditiously. The next process is to suspend a number of zig-zag bars in pairs on a bench fitted with iron horses, and to thread over them the loop bars, allowing one loop bar for each bottom point of the set of zig-zags, two of the latter passing through each loop. Straight bars are then placed in between the zig-zag bars at each loop, and the zig-zag bars are then crossed over these straight bars and bent down until their upper apices again cross those of their neighbors from the next loops. Into the forks thus formed at the top are slipped straight bars, and over the latter and under the heads of the zig-zags are run straight cross-bars.

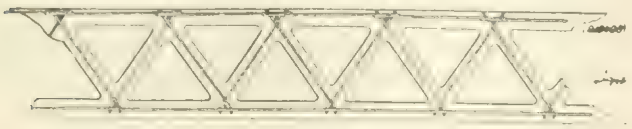


Fig. 2.

The reinforcement is made in pieces usually 20 ft. to 24 ft. long and from 6 ft. to 8 ft. wide. It is rigid, and bars cannot be displaced.

It is customary to lay it on the formation surface and to put down concrete sufficient for a depth of 2 in. through the spacings. The framework is then lifted till it rests on the top of this 2-in. layer, when concreting is resumed. This method ensures the concrete covering below the bars.

The same method had been applied to other works, as for instance, to hollow walls. The cores in this case would be seen end-on, on the section C D. The cores are triangular in section, and result in a wall of two surfaces reinforced by diagonal partitioning in a manner which will be evident by further reference to Fig. 2.

Reinforced Concrete Dam for Controlling Inrush of Water in Mining Tunnel

From Concrete and Constructional Engineering, London.

In a paper read before the South African Institution of Engineers Mr. Thomas Blandford described a reinforced concrete dam employed for shutting off an inrush of water at Modder East. This dam was constructed in the 3-19 rise at No. 1 shaft, for the purpose of controlling and closing off a feeder of water which yielded approximately 1,000,000 gal. per day at a pressure of 500 lb. per square inch. This outburst was met in the dike through which the rise was being driven, and was found to be coming from a vertical fissure striking north and south. As soon as it was found that any temporary measures for reducing the quantity of water were useless, work was immediately taken in hand to build a reinforced concrete dam. A good concrete, consisting of 1 part cement, 1 sand and 2 broken stone (dike material on site), was well rammed into the face to a thickness of approximately 4 ft. No hitches for support were cut in the rock, but a series of forty 1-in. steel pegs were driven to a depth of 6 to 9 in. into the rock in two rows around the perimeter of the drive, such pegs projecting a distance of about 1 ft. 6 in. into the mass concrete. In addition to this, two rows of ½-in. bar iron, one vertical and one horizontal, the bars being about 1 ft. apart, were embedded into the concrete during construction and tied up by means of wire to the above-mentioned pegs, thereby forming a double grille system of reinforcement. In this way a thoroughly strong wall was obtained.

The feeder of water was confined behind the concrete to as small a channel as possible with the aid of 21-gauge steel sheets, and released through two 6-in. pipes fitted with stop valves. By this means it was possible to place the concrete in position correctly without any interference from the water. Six 1½-in. cementation pipes were also built in the dam for the purpose of filling and solidifying the fissure and the subsequent testing of the ground in advance. The work of construction of the dam occupied two days, being commenced in Aug. 14, 1919, and completed on the 16th, after which it was allowed to set for three days. During this period the feeder was flowing freely from the 6-in. drain pipes. Injection was then started on the 19th and continued until the 27th, when all the pipes in the dam had been solidly closed with cement, and also two of the release holes in the hanging wall. At this stage approximately half the original feeder was shut off, but owing to shortage of cement it was not deemed advisable to close it all off, as there was no cement on hand should anything unforeseen take place by totally closing off the water, taking into consideration the short period that had been allowed for the maturing of the concrete.

Cylinder Pier Foundations for Concrete Wharf.—A system of cylinder pier construction, differing in some respects from that which has been largely employed in reinforced concrete wharves on the Thames and elsewhere in England, is now being adopted in the construction of a reinforced concrete wharf 2,600 ft. long by 142 ft. wide, forming part of the Prai River Port development scheme, Federated Malay States, according to the Times Engineering Supplement (London), of December, 1920. Reinforced concrete cylinder piers, made up of short pre-cast sections, are sunk in steel guides. The bottom section for each pier has an extended base which is provided with a cutting edge, 3 ft. 6 in. deep, 11 ft. 6 in. in diameter outside, and 9 ft. 4 in. in diameter inside. The other sections are 8 ft. 6 in. in diameter, the edges are shaped so as to make a key joint between successive sections, and the top section is fitted with a cap after the interior of the cylinder has been pumped dry and filled up with plain concrete. The cylinders are braced at the top by members forming part of the reinforced concrete superstructure. Borings on the site showed that under the river mud there was a bed of sand of great depth, and the cylinder foundations were adopted in preference to screw piles, owing to the rapid deterioration of steel in the Prai River.

Use of Chlorine Gas in Water Sterilization for British Army

From The Times Engineering Supplement, London, December, [illegible]

An account of the methods developed during the war for sterilizing water in the field by means of chlorine was given by Captain J. Stanley Arthur before the Institution of Mechanical Engineers.

He stated that the best methods of filtration can bring about a reduction of 98 per cent of the total number of bacteria present in water, and to remove the remaining 2 per cent, and thus render the water perfectly safe a process of sterilization is necessary. Bleaching power was first employed to sterilize a supply of drinking water at Maidstone in 1897 during a typhoid epidemic, which was very rapidly stamped out, but gaseous chlorine, though used to a small extent in America for some time, has come into general use only during the last few years. The amount of chlorine, whether as gas or from bleaching powder, required to sterilize water is quite small. For a sedimented and filtered water half a part per million is sufficient for complete sterilization, and for a crude water, as from the Thames at Kew, three to four parts per million are required, provided that the chemical is allowed to remain in contact with the water for at least 20 minutes.

Use of Bleaching Powder.—At the outbreak of war the only method of water purification that could be carried out in the field was embodied in the water cart. In this apparatus the water was pumped from the source, treated with alumininum sulphate, with or without the addition of an alkali and filtered through a cloth-covered cylinder on which the aluminium hydroxide produced by the hydrolysis of the aluminium sulphate was deposited and formed the real filtering medium. After filtration the water was sterilized by bleaching powder. It was soon found that more of this substance was being added than was necessary to produce sterilization, and attempts were made to devise a simple method by which the necessary amount could be determined in the field. The first suggestion was made by Professor James Woodhead, and the actual details that resulted in the fitting up of a case containing the necessary apparatus and chemicals with instructions for carrying out the test were worked out at the Royal Army Veterinary College under Sir William Horrocks. With this test case, known in the Army as "Case, Water Testing, Sterilization," and the water-cart as starting point, the whole of the great water purification scheme of the army has been built up.

The first advance on the water-cart was a plant that sterilized water by a continuous process at the rate of 125 gal. an hour, using bleaching powder, and then a larger and much better plant was developed, giving a continuous output of 400 gal. an hour, in which the excess of chlorine left in the water after sterilization was removed by a solution of sodium bisulphite. These plants were fitted on 3-ton motor-lorries, and a large number were sent to France.

Adoption of Chlorine Gas.—The output of these plants was relatively low, and a considerable amount of work was entailed in making the solutions. Attempts were made to overcome these defects, and finally, by the use of chlorine gas, a new type of water-purification plant was devised which has been adopted, with minor alterations, to meet special conditions, as the standard in the British Army. The great difficulty was to find a satisfactory method of administering the gas to water, but Wallace & Tiernan of New York, working on the lines of a patent taken out in 1912 by Major Darnell of the United States Army, produced two types of chlorinators which have proved very successful in operation, and both of which have as an object the delivery of a continuous supply of chlorine to water at a known indicated rate, independent of any changes of pressure of the chlorine in the containing cylinder.

Tests made on canal water at Brentford, Middlesex, with the first instrument brought to England in August, 1916, showed that the water so treated had a far less marked taste than when similarly treated with bleaching powder. During the tests the use of sulphur dioxide gas was suggested for the removal of the excess of chlorine left in the water, and therefore, of the slight taste imparted to it, and this method has been adopted as the standard for all types of water purification plants, except those that are too small to admit it to be economically used.

Of the two types of the Wallace & Tiernan apparatus, the direct-feed chlorinator, which has been adopted throughout the Army purification plants, is essentially an apparatus which meters chlorine gas and delivers it at constant pressure, the gas being added directly to the water under treatment. It consists of three main parts—a compensator for compensating alterations of pressure in the chlorine cylinder; a metering or flow-measuring apparatus; and a check or back-pressure valve and diffuser. Entering the compensator at any pressure the chlorine, after passing through it to the orifice, is metered and leaves the apparatus at constant pressure, to be forced into the water through the diffuser, which breaks it up into very small bubbles. In the solution-feed type the chlorine, after leaving the compensator, passes to a bubble meter in which the bubbles or chlorine are seen and counted and are dissolved in water, the solution being afterwards injected into the water that is to be sterilized.

Army Plants.—The Army purification plants in which the chlorine-sulphur dioxide process has been adopted nay be divided into three classes: (1) Portable plants built on motor-lorries; (2) portable plants on barges; and (3) stationary or land plants. The first class is primarily for use with an army moving into occupied territory, in which the usual sources of water have been destroyed or rendered useless. The second serves to some extent the same purpose, but on a larger scale, and the third is the standard type for supplying water to troops in the area of operations and for replacing the water supply of towns. In field operations the purified water is either delivered to storage tanks and thence to pipe lines, or, as with mobile purification plants, to tank lorries or water-carts. The small amount of chlorine purposely left in the water generally disappears by the time it reaches the troops, and consequently no taste of the chemical can be detected.

Physical Properties of Clay in Relation to Pile Driving

From The Times Engineering Supplement, London, October, 1920.

Two papers describing investigations on the physical properties of clay in relation to pile driving were presented before the Society of Engineers, one by Mr. Alfred S. E. Ackerman, and the other by Lieut.-Col. Henry R. Lordly, of Cornell University, U. S. A.

Resistance of Piles.—Mr. Ackermann dealt with the results of 107 experiments made in continuation of the 102 which, as described in a paper he read before the same institution in March of last year, he had carried out by forcing two forms of pyramid into clay.

These new experiments confirm the conclusions drawn from the previous ones, except in one or two particulars, and have also enabled him to make some fresh deductions. They show that clay increases in tensile strength as its water-content decreases, and that its contraction on drying increases as its original water-content increases. The work necessary to cause a pyramid or other tapered body to penetrate clay containing a moderate amount of water is utilized in (1) overcoming the friction or adhesion, and (2) causing displacement alone, the former being by far the larger quantity. The work done per cc. to cause displacement by means of tapered bodies is constant and independent of the depth, so far as the experiments have gone, for any set of conditions; in other words, for tapered bodies and a given percentage of water in the clay the surface of contact is directly proportional to the load causing penetration. The work done per cc. in causing displacement alone, i.e., excluding friction, is not independent of the angle of the pyramid, but increases with that angle, and the work done in causing displacement by means of a disc (in which no work is done against friction) is greater than that done in the case of either form of pyramid. The co-efficient of friction is not independent of the pressure of the clay on the surface, the friction or adhesion increasing with the pressure. The relation of the horizontal pressure to the vertical depth may be determined by the penetration of a pyramid or by the adhesion of clay to a plane surface of the same material as the pyramid. The pressure of fluidity appears to be considerably reduced if the clay has been allowed to become thoroughly air-dried, and is then wetted and puddled, and it is affected within limits by the horizontal size of the container of the clay. The volumetric displacement caused by a steel ball falling upon a surface of clay is directly proportional to the height of fall.

Some experiments were made with chalk. Wet chalk, both powdered and precipitated, showed some similarities in physical properties to clay, but the differences were more striking, and the differences as between powdered and precipitated chalk were perhaps even more marked than as between clay and chalk. Powdred chalk containing 25 per cent of water was found to have a "resistance point," where the curves showed an extra resistance at which no increase of penetration took place for the increment of load—the reverse of the phenomenon of the yield-point of mild steel when it is tested in tension. With chalk the effect of the container was more marked than with clay. Wet powdered chalk has a modified pressure of fluidity, and the water-content greatly affects the properties. Wet chalk practically does not contract in drying, and its adhesion and cohesion are much less than those of clay. Clay is hygroscopic and chalk is not.

Grouping of Piles.—Lieut.-Colonel Lordly's paper referred in particular to tests made on the grouping of piles with the object of ascertaining the minimum distance apart at which they can, or must, be placed in clay in order to give the most effective results. These tests formed part of a series similar in character and in results to those carried out by Mr. Ackermann.

The piles employed were 3 ft. long, and their diameters varied from ¾ in. to 2½ in. Dead-weight loads were applied in increments of 20 lb. and 50 lb., and the maximum total load in any one test was about one-third of a long ton. The total penetration was up to 3 ft. The clay was contained in bins having a capacity of 2 to 4 cu. yd., and its water content was about 25 per cent.

Group tests were arranged to determine the effect on resistance of driving the piles in various groups at various distances apart. The difference of the resistance of each pile in a group was compared to that of the first pile driven. This pile was always placed more than two or three diameters away from any other pile and was designated a "free" pile. The piles in the groups were neither one diameter apart or slightly more or less than that distance; the results were compared with the resistance of the "free" pile of a group, and also with that of piles that varied slightly from being one diameter apart in other groups.

The results indicate that piles driven in a plastic clay or sand between other piles at a less distance than one diameter between their outer sides and the inner sides of the adjacent piles have a greater resistance than the same piles driven free and unobstructed. The exceptions would probably be cases in which square and round piles of various sizes are intermingled, though without further tests this is questionable. If the grouped piles require a heavier driving load, they should also carry a heavier dead load than the free piles. This raises an interesting question. If 12 piles are to be placed in clay over a certain area, which is preferable—four groups of three closely-driven piles or 12 piles distributed as free piles over the whole area? If the practical aspect of the construction of the top grillage is the same and the loading can be properly distributed, the author would prefer the four groups of three piles. The extra resistance of the middle pile can remain unstressed, as a reserve power, the load being equally distributed on the basis that all are free piles, and thus provide an extra resistance as a safety factor in case of overloading at any time.

The author also undertook a series of tests with the object of demonstrating ocularly the actual displacement of the clay caused by driving a pile into it. For this purpose a box with a glass front was used. A number of horizontal lines, indicated by white sand, were arranged in the clay against the glass front, and the displacements of these lines as the piles were driven down were photographed. The results were similar in all cases and proved the side displacement to be at least one diameter of the pile.

The question arose, however, whether the clay was influenced by being against the glass, and also to what distance back the clay was displaced by the action of the pile. To obtain this information X-ray photographs were taken. The clay was contained in a box having a thickness considerably more than the diameter of the pile and of sufficient breadth and height to permit a natural movement of the clay body as the pile was driven down. Tests were made with wet and dry sands and with wet clay. The horizontal lines were represented by fine iron filings, and in one test sands of various grades of fineness were used. The curves obtained conformed to those in the glass-box test, and prove that the latter represents approximately the actual conditions.

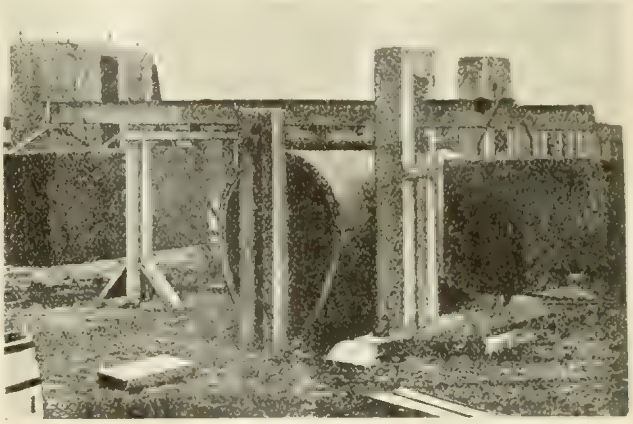
The author considers that the experiments justify the deductions that in a clay soil there is a particular distance apart at which piles should be spaced in a group in order to get the best bearing efficiency; that the minimum lateral displacement in a clay soil, or in sand, extends to at least one diameter of the pile in all directions; that to get the greatest bearing efficiency when grouping piles in a plastic clay the middle pile of any group should not be more than one diameter distant from the adjacent piles, outside measurements from pile to pile being taken, and that a group of small or medium-sized piles in plastic clay should give greater efficiency than one large pile or two of medium size. As regards the last deduction, the ratio of the end bearing to side friction must be considered in each case. Experiments made by the author show that the side friction is greater than is generally supposed.

Reinforced Concrete Pipe for Geelong, Australia Sewer System

By E. G. Stone.

From Commonwealth Engineer, Melbourne, Australia.

The sewage scheme installed by the Geelong, Vic., water and sewage trust embraces several leading features in reinforced concrete work. The writer patented for this work a new system of making reinforced concrete pipes. Strong molds of steel plate were built on wheels. These were brought after erection, with reinforcement in them, under the receiver, which was filled by machine-mixed concrete. Compressed air was applied, and then concrete deposited under a pressure of 70 lb. per square inch. Special ventilating holes were introduced, and all surplus water that had to be used in mixing to get a thin mixture was pressed out of the concrete. With this method the pipes could be handled within six hours after casting. All the work was done in organized steps, the following scheme being adopted: After casting the pipes, within one hour the ends of the molds were removed and left hanging on a traveller; the top mold was then removed and also left hanging; the truck was then wheeled out into the yard, allowing the concrete in the pipe to harden further. The pipe was then lifted by the internal mold and upended. Then the inner mold was removed in two sections. The inner mold was then re-erected and placed on the truck with the reinforcements round same. The truck was then taken under the traveller, the top molds and ends put on, and the reinforcement adjusted by spacers in its exact position, and then brought under the receiver and filled. The tests of these pipes were severe. They were to be built to stand a load of 1,800 lb. per lineal foot, placed as a concentrated weight along a 4-in. rolled steel bar. An internal pressure of 30 ft. head of water was considered sufficient.



Method of Testing Concrete Pipe.

The laying of these pipes was interesting. Ten miles of 2 ft. 6 in. railway track gauge were laid for this work, and the handling was principally done by two steam locomotives, the pipes being carried upon specially shaped trucks. One difficulty raised against the use of long pipes was the suggested trouble of placing them in the tunnels, of which there were over two miles in the work. A truck was designed to get over this, and very little trouble was experienced.

The joints of the pipes were made under compressed air with a small portable petrol-driven compressor. The longitudinal reinforcement of the pipe projected at the ends and was incorporated into the joint reinforcement, so that a continuous pipe line was the result.

Improvements in Mechanical Filtration

From Water and Water Engineering, London, Nov. 20, 1920.

The chief difference in the various systems of mechanical filtration lies in the method employed for cleansing the filtering material, and it is chiefly in this cleaning operation that a great advance has been made within recent years. The aim has always been and still is to get the maximum possible cleaning effect with the minimum consumption of wash-water, and also to simplify the construction of the filters and eliminate, as far as possible, mechanism inside the filters, provided this can be done without decreasing the efficiency.

The enormous rise in the cost of material and labor due to the war has focussed the attention of authorities upon the advantages of simplicity of construction when allied to efficiency. The method of scouring the filtering material by means of compressed air according to the Candy Filter Co.'s system is an advance of considerable importance in the history of mechanical filtration. This system is known as the "air-scour," and in practice the compressed air is forced upwards through the filter bed from special nozzles in the bottom of the filter for from three to five minutes, and is then followed by the upward wash of water. The air agitates and scours the filtering material, producing the same results as the water jets, and the loosened dirt is carried away by the upward wash. In the Candy system the difficulty of ensuring of an even distribution of the air is overcome by a patent air nozzle. The nozzle is equally suitable for either pressure or gravity filters. The nozzle has a lengthened stem with an additional aperture in it near the top. When the filter is filtering, the nozzles serve to collect the filtered water and prevent any of the filtering material passing into the filtered water outlet. For this purpose packing layers of coarse material are placed over the nozzle plate and above these the fine sand is laid. During the cleaning operation the compressed air is delivered into the bottom of the filter. The aperture at the top of the stem of the nozzle is exactly proportioned to pass the required quantity of air. It is only by employing a proportional aperture to take the air that the best distribution can be secured, otherwise the greater proportion of the air would tend to pass up the first large hole it came to. As soon as the air scour is completed, the upward wash is turned on and the water passes up through the stem of the nozzle. Thus the water passes through the comparatively large bore of the stem while the air is restricted to the smaller aperture at the top of the stem, and these two are proportioned to pass the correct quantity of water and air respectively.

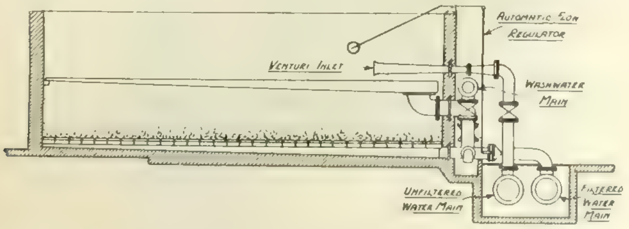


Fig. 1—Candy Patent Rectangular Gravity Filter.

Following on the introduction of the Candy air scour system have been:

The invention of the Biflow filter. In this the filtering body is double the usual depth and comprises in effect two filter beds, one directly superimposed on the other. The upper bed filters downwards and the lower bed filters upwards, and the whole of the filtered water is taken from the middle of the filtering body by means of special collectors. In this way double the filtering area of the ordinary filter is obtained, and a very important economy is secured. The cleaning of the filter is effected in exactly the same manner as an ordinary air-scoured filter described above. The nozzle plate on which the whole filtering material rests is fitted with the patent air nozzles, and the air and water for cleaning the filter pass vertically upwards through these nozzles through the whole bed. The first of these filters was erected for the Uckfield Water Co., and has been in entirely satisfactory operation for two years.

The construction of large rectangular gravity filters built in reinforced concrete brickwork, or with the Candy system of steel sides embedded in a concrete floor. This system of construction is now being used for many large schemes of filtration.

The special drainage floor is a very important feature of the gravity filters and is formed of stoneware drain pipes arranged in rows across the filter, and fitted with brass plates in which are screwed the air scour nozzles. The pipes and plates are concreted in the floor of the filter and form a permanent drainage system. Each row of pipes has its own connection to the compressed air supply, and drains into a channel running the whole length of the filter and connected to the filtered water outlet pipe. This floor is absolutely permanent and has the great advantage that no water can have any corroding effect upon it. The wash-water is taken off in a trough, which is supported above the filter bed. The Candy gravity filter is illustrated diagrammatically in Fig. 1.

At the present time the Candy Filter Co. is constructing the first unit of a gravity filter plant for the Shanghai Inland City Waterworks. These filters are built with steel sides, and each unit is designed to deal with 1,000,000 gal. per day of the Whangpoo River water.

A great advantage of the Candy system of gravity filters is that potential filtering "head" can be obtained by a draw on the filtered water outlet as well as by a column of water above the bed. Normally, a filtration head of 10 ft. is necessary, and this can be secured either by building up the walls above the filter bed or by leading the filtered water in a pipe to a point of lower pressure. This result can be obtained in pumping schemes by connecting the pump suction direct to the filtered water outlet, and in gravitation schemes by running the filtered water pipe into a reservoir at a lower level.

An automatically governed valve on the filtered water outlet, and a flow indicator that shows the filtration rate of the bed at any moment, are other important features.

Lead Poisoning and Water Supplies

Editorial in The Surveyor, Feb. 18, 1921.

It is doubtful whether all the dangers of lead poisoning are event yet thoroughly grasped. The symptoms of lead poisoning extend over a wide range, and many ordinary ailments which tend to lower the health of the whole population may sometimes be due to this cause. The necessity of scrutinizing the condition of all public water supplies with reference to the question of plumbo-activity is emphasized in a paper read by Mr. James F. Reade recently before the Institution of Civil Engineers of Ireland. The application of the paper is no doubt chiefly to Ireland, where the possibilities of lead poisoning from water are, on the whole, greater than they are in this country; but it must not be imagined that the danger is any greater in Ireland than it is in many parts of this country.

The author points out that special attention should be given by those responsible for public health to the existence of what may be called disguised or obscured plumbism, so that, whenever a lowering of the general standard of health is observed, consideration should be given to the part played by the domestic water supply as at least a possible contributory cause ranking with such well recognized evils as indigestion, colds, malnutrition, insanitary surroundings, and bad housing conditions. It should be observed that the danger is sometimes very great in the case of isolated private supplies; the apparent purity of the water is no safeguard, as even pure distilled water is commonly found to erode lead vigorously. Rain water and snow water are similarly dangerous, and water which contains humic acid derived from peaty gathering grounds is, of course, known to be very dangerous. Water drawn from wells and river water has been found in many instances to have a capacity for acting on lead. This is very important, in view of the fact that our new supplies will have to be drawn from rivers in many cases.

Mr. Reade is of opinion that the usual water analysis gives no indication of the plumbo-solvent or erosive character of the samples examined, but this surely presupposes that the engineer has failed to ask for such information. He draws attention to the need of engineers making a careful study of the surces of their supplies, and keeping records in some prearranged systematic manner. The nature of underlying rocks on gathering grounds should be carefully studied. Contact with certain rocks may be sufficient to neutralize the acid present in water which would be likely to act upon the lead. Also soluble salts taken up from the rocks may confer and intensify acid neutralizing power sufficiently to resist the influence of a considerable influx of acid water and thus prevent its lead solvent power. On the other hand, water that is not plumbo-solvent may become so owing to an access of acid water from a peaty area.

There are many similar factors to be considered, and these are given in the author's paper. The methods for treatment of plumbo-solvent water are given, viz., the powdered chalk, lime, or carbonate of soda mixing method adopted by towns in the North of England, and the passing of the waters through filters on which a layer of lime has been spread, or of which the coarser parts of the body of the filter are constructed in broken limestone. For the treatment of water which has plumbo-erosive power, which should not be confused with plumbo-solvent power, treatment with carbonate of soda after filtration through sand and limestone is recommended. The paper is of considerable interest, and certainly suggests that greater care should be given to the scientific investigation of the possibility of lead poisoning in a minor degree being more prevalent than is usually supposed.

Railway Construction in Unstable Grounds

From The Railway Engineer, London, March, 1921.

While construction in unstable ground cannot definitely be governed by pre-arranged plans, there are certain cardinal principles which should be observed. These may be summarized as follows:

(a) Any such work should approximate in weight to that of soil displaced.

(b) Such weight should be evenly distributed as far as it is possible.

(c) All longitudinal open trenches should be very short, and cross trenches very narrow.

(d) All trenches excavated for that purpose should be filled solid with masonry or concrete.

(e) All timber lining should be removed as the work progresses.

(f) All materials and workmanship should be of the very best.

As a typical example, a construction will be described of a shallow arched covered way for a double line of railway throughout the foot of a London clay-hill, with foundations of the same material. The surface of the ground is presumed to be on a transvere slope flatter than its natural angle of repose, with the strata dipping in the same direction.

The side walls should be constructed first of all; and be carried up to the springing of the arch in solid concrete, the wall above such springing being built up to within a foot of the surface of the ground on both the high and low side.

Whole timbers strongly fished should be let into the ground stretching from wall to wall. These timbers will be removed as the work progresses.

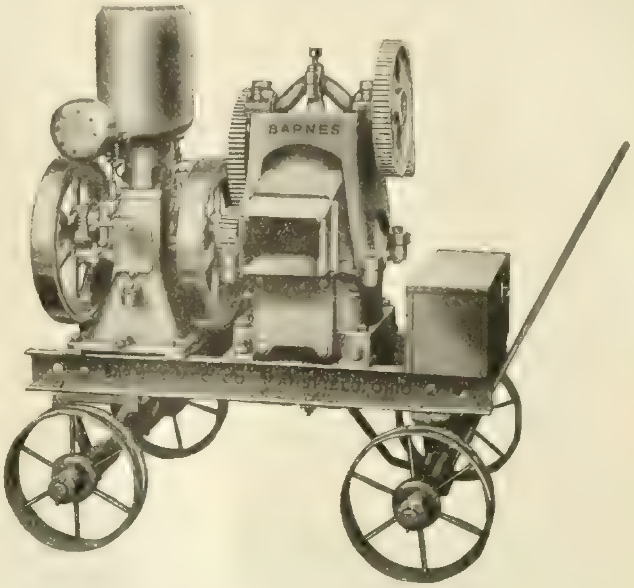
The excavation of the center dumpling should then be carried out down to the intrados of the arch and formed to receive a centering. The arch should then be turned in short lengths and the spandrels be filled with concrete up to the top of the retaining walls, thus forming a strong continuous buttress to the upper walls.

The rings of the arch should be locked together by means of bricks on end through two of them. The real dumpling under the arch can then be removed, either by means of holes left in the arch or from the two ends, and should be carried down to the foundations of the invert. The skew-backs of the arch should be cut out of the side-walls. The spandrels should be filled with concrete and shaped to the form of the extrados of the arch, the rings of which should be locked as above. The invert should be filled first with very coarse ballast, and topped with any kind of permanent way which may be selected by the responsible engineer. The voids in the coarse ballast will allow any seepage to flow, as no part of the covered way should be level.

Should such instructions be carried out carefully no movement in the surrounding soil is likely to take place.

Two Pumps in One—A New Convertible Diaphragm Pump

A new convertible diaphragm pump has just been placed on the market by the Barnes Manufacturing Co., Mansfield, O. This pump can be quickly converted from the open spout "anti-flush" type to the closed spout "odofor" type—thus giving a pump for ordinary drainage work or one that will force the liquid above the pump, discharging through a hose or pipe instead of trough and handling sewage or the contents of catchbasins in an odorless, sanitary manner. The new pump has many exclusive features. Its overhead jack construction eliminates a great many working parts, the forged steel crank shaft replacing about 15 or 20 parts in the old walking beam construction. In addition to having fewer parts this overhead jack construction is stated to be much stronger and will give longer life on account of its long bearings and heavy working parts. The diaphragm is held in place by a clamping ring which is separate from the jack so that the latter does not have to be disturbed when the diaphragm is replaced. The suction valve is especially noteworthy. It may be removed for inspection or repairs without disturbing the suction hose. This is a very important point since it is often difficult to replace a hose so as to have all joints air tight. This valve is more efficient and has longer life than the old rubber flap valve. In addition it may be faced with any kind of sheet rubber, leather or canvas and does not require high grade material which is hard for the contractor to obtain. The pump is adapted to handling all kinds of drainage work such as pumping out trenches and excavations of all kinds. It is stated to have a capacity of 10,000 to 12,000 gal. per hour.



Barnes Convertible Diaphragm Pump.

Economy of Dry Sand in Concrete.—Recent investigations have brought out a point of much importance to contracting firms—namely, that in cases where concrete is proportioned by volume as customary, the use of wet sand requires from half to one bag more cement than is necessary for the same sand in a dry condition. As sand is usually wet or moist when used, the full effect of the difference between wet and dry sand may not be apparent under ordinary working conditions. Nevertheless, the employment of sand which has recently been exposed to rain entails the use of more cement than would be required if the concrete were mixed on a dry day. The explanation is that moist sand will not pack so closely as dry sand, and that the voids to be filled by cement are proportionately greater in volume. It is true that the strength of the concrete increases with the amount of cement, but any such excess of strength is unnecessary and wasteful, if the requisite strength is obtainable with a smaller amount of cement and dry sand. The same considerations also apply to aggregates in varying measure according to the dimensions of the particles, the finer material being affected by moisture more than the larger fragments of stone.—The Times Engineering Supplement (London), November, 1920.

Roads and Streets Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Should Prices Be Regulated?

It is the consensus of opinion of business men that free competition is not an unmixed blessing. Indeed, there has been a growing sentiment in favor of restricting competition and coincidentally of regulating prices. For example, the editor of Engineering and Mining Journal recently (Feb. 12) said:

> We have always been accustomed to believe that competition was "the life of trade," and that control and the elimination of competition were ruinous or iniquitous. But when we inquire into some of our mining industries, like the graphite industry or the barite industry, we often find them almost hopeless because of competition; and it is easy to diagnose that they need scientific and statistical studies, standardizing of product, and central marketing, if they are to find markets and maintain themselves in competition with foreign products.
>
> In other industries the remedy of organization has been found necessary. The California Fruit Growers have changed from bankruptcy to prosperity by a centralized control over supply, grade and marketing. The eastern farmers sorely need such centalized and scientific methods of maketing. Labor has found centralized organization better for its welfare than competition. The organization of banks into a Federal Reserve system has recently avoided a panic.

We may add the significant fact that the "Solid South" has been breaking away from the traditional free trade doctrine of the Democratic Party, because unrestricted competition with foreign countries can no longer be regarded with equanimity.

Competition is undeniably a splendid tonic, but taken in huge doses it often kills the patient. One of our great economic problems is how to secure the most efficient quantity of this tonic.

The prices of many things are already regulated and we seem to be traveling toward more extensive price regulation. Some prices are regulated by monopolistic corporations, some by "associations," some by the public through public utility commissions. Will all prices eventually be regulated by the public? We doubt it, yet we do not doubt that the public will have a voice in determining what the prices of many things shall be.

Unquestionably the public will eventually demand such control over currency and credits as to prevent wide oscillations in the general price level. Failure to exercise such control is at the bottom of the present hard times, not only in America but in Europe.

In another article in this issue the editor discusses Public Regulation of Industry.

Suppressing the Personal Pronoun

The average Anglo-Saxon is so fearful of being considered egotistical that he has invented several circumlocutions to be used in place of the personal pronoun. Some of these are: "The author," "the writer," "the speaker." Prof. P. B. McDonald, assistant professor of English, New York University, has recently "seconded the motion" to discontinue these circumlocutions. He says:

> In spite of the practice of such famous engineers as Milo S. Ketchum, who avoids "I" wherever possible, authorities on technical writings are fairly well agreed that to say "the writer" in a signed article is really more self-conscious and affected than to say "I." T. A. Rickard, for instance, in his "Technical Writing," encourages a moderate use of "I."
>
> Some writers avoid "I" by using the passive and resorting to other awkward devices. Thus one engineer wrote: "The following report of the plant was made." This is indefinite. Did the engineer himself make the report, or perhaps his assistant, or someone else? When anyone talks of himself or writes his own opinions why not say "I"?

And we repeat, why not?

Several years ago during a trial before a public service commission, an appraisal engineer was quoted by one of the expert witnesses, in order to show that the witness had authority for his theory. An engineer on the opposing side asked permission to look at the text that had been quoted. It began: "The author holds the opinion that, etc.," but the sentence following the quotation was: "The writer, however, does not agree with the author." Members of the American Society of Civil Engineers will recognize the convention by which the author of a paper must call himself "the author," whereas any one discussing the paper must call himself either "the writer" or "the speaker." Here was an instance where this stilted method of avoiding the personal pronoun led to a serious error on the part of an engineer who thought he was quoting the opinion of another engineer, but was not.

Is there not, at bottom, fully as much egotism in the studious avoidance of the pronoun "I" as in the use of it? The writings of French engineers abound in "I's," whereas the converse is true of English technical writings. Can we measure the relative egotism of the two nations by ascertaining the number of "I's" per 1,000 words in their respective technical books and periodicals?

Should Not the Annual Road Convention and Exposition Be Held in a Central City?

It has been the practice to hold the annual convention of the American Road Builders' Association in different cities, regardless of the centrality of their location. Last year the convention was held at Louisville, Ky., this year at Chicago. The contrast in the attendance at these two conventions was marked. Even more noteworthy was the difference between the machinery exhibits at these road expositions. Were the road convention merely a conclave of road builders, with no exposition of machinery, it would probably be well to continue the practice of holding it in different sections of the country each year. We believe, however, that so long as the machinery show remains one of the chief attractions, it would be preferable to make one large, central city the annual meeting place, or at most to rotate annually between two cities.

The American Railway Engineering Association holds its annual convention every year in Chicago, and the railway machinery and appliances exposition occurs at the same time. The result is an attendance and a "show" that is uniformly large and attractive. Manufacturers can not easily be induced to exhibit in cities that are not large and central. The directors of the Railway Engineering Association have learned this lesson, and now act accordingly.

Would it not be wise for the directors of the Road Builders' Association to seek the opinions of the exhibitors of road machinery and materials before selecting the site of the next convention and exposition?

The Government's Report on California Highways

In our issue of March 2 we published abstracts of a criticism of California state highways, written by engineers employed by two automobile clubs. We also published a reply by the California Highway Commission, and an editorial in which we said that the criticisms seemed not to be warranted.

Elsewhere in the present issue we give an abstract of a report by the U. S. Bureau of Public Works, in which substantially the same conclusion is reached as in our editorial of March 2.

We now have the full report of the engineers of the California automobile clubs, further abstracts from which will be given in future issues.

There are excellent data and discussions in this critical report. The pity is that such a report should not have been made to some engineering society rather than to a non-technical club, few of whose members are capable of weighing the evidence or of following the arguments.

The government report is far more judicial in tone and correspondingly more convincing. It is also characterized by a more scientific classification of the condition of road pavements.

Is "Trust" Control of Prices Disclosed by Price Curves?

The editor of Engineering and Mining Journal makes the following suggestive statement:

> Were there any suspicion in our minds that there existed a secret and efficient (copper) "trust," the curve of copper prices [illegible] we [illegible] that the degree of organization and effective control in any industry may be decided from a study of the price curves. Note, for example, the gentler curve for zinc, as compared with that for copper. And, on reflection, we remember that the zinc industry is actually far more "controlled" than in the case of copper. Copper, as we pointed out editorially in our issue of Dec. 18, is a sensitive barometer of industrial conditions: as sensitive, apparently, as the stock market; and a more extreme exemplar cannot be given.

The same editor points out that "the aluminum industry is a monopoly" and that the monthly price curve of aluminum has shown only gradual changes through relatively narrow limits. Similarly as to nickel for "the nickel industry is closely held, the International Nickel Co. predominating in the world situation."

Whether such price control is advisable or not is discussed in another editorial, also in a signed article by the editor of Engineering and Contracting in this issue.

Detroit Engineers Have Opportunity to Expose Municipal Ownership

A few of our large cities show a decided leaning toward municipal ownership of public utilities. We trust that Seattle and San Francisco on the Pacific Coast will find imitators on the Atlantic Coast and in the Mississippi Valley.

Seattle and San Francisco have thus far failed to run their municipal railways in a way to excite enthusiasm for municipal ownership, but this has not deterred Detroit from trying the same sort of experiment. Detroit is building a street railway, and has yet to taste the flavor of annual deficits from its operation. Perhaps this accounts for the fact that the City Council of Detroit has decided to submit to the voters a charter amendment authorizing the city to manufacture cement, sewer pipe and brick, and to acquire sand and gravel pits. We hope that the citizens of Detroit vote in favor of such municipal operation, provided the city will keep and publish unit costs of operation. However, we anticipate that Detroit politicians will manage to conceal the real results of municipal ownership, unless public-spirited citizens force a periodic revelation of the unit costs.

The civil engineers of Detroit will perform an invaluable public service if they themselves undertake to make an annual audit of the costs of operating municipally owned utilities. Costs speak louder than theories, and may be relied upon to argue more effectively than all the political orators who seek to combat them.

Is There a Corner in Good Roads Discussion?

To the Editor: I note with interest a letter by J. B. Marcellus published in your issue of March 2. Mr. Marcellus asks the question, "Is there a 'corner' on the discussion of 'good roads' due to lack of interest in the rest of the United States?" Permit me to answer that there is no "corner" on highway thought and discussion, but that certain sections of the country have failed to respond to the good roads stimulus as other sections, as the following facts will show:

An anlysis of the speakers at road conventions and the writers on road matters in periodicals shows that the men active in these matters reside for the most part in an area constituting about one-fourth of the country.

The two chief highway organizations in this country are the American Road Builders' Association and the American Association of State Highway Officials, and in view of this fact, it will be of interest to analyze the programs of the recent conventions of these bodies. The official program of the American Association of State Highway Officials recently held in Washington contained the names of 31 highway officials. Of these men, 6 per cent were from the U. S. Bureau of Public Roads, 32 per cent were from and east of Pennsylvania, 71 per cent were from east of the Mississippi and 22 per cent from west of the Mississippi.

Now, analyzing the territorial distribution of the 32 men on the program of the recent convention of the American Road Builders' Association, we find that 18 per cent were from the U. S. Bureau of Public Roads, the U. S. Bureau of Education and the Federal Highway Council, all national bodies; 37 per cent were from and east of Pennsylvania, which includes a number from Canada and two bankers who are really national figures; 72 per cent were from east of the Mississippi and 9 per cent were from west of the Mississippi.

The close similarity of the above figures is no accident, but shows that a small part of the country holds the greater part of the road builders who have something to say and who are willing to say it. And also, since the membership of the American Association of State Highway Officials is more evenly distributed, only 9 per cent of the total membership of the American Road Builders' Association being west of the Mississippi, the Chicago convention of the latter body well represented the interest of the West.

The states of Pennsylvania and New York together have over $70,000,000 available for highway work. Illinois is just starting to spend $60,000,000. The territory lying east of the Mississippi, about one-fourth of the total area of the country, has available for highway work approximately 50 per cent more than has the remaining three-fourths of the country west of the Mississippi.

If Mr. Marcellus will glance again at the program of the Chicago convention, he will find that three instead of two men come from west of the Mississippi, and that 12 men, including a member from Canada and two national bankers, instead of 17, are from and east of Pennsylvania.

The 1920 proceedings of the American Road Builders' Association were consulted on the facts relative to membership distribution given above.

Long Island City, L. I. C. A. LEWIS.

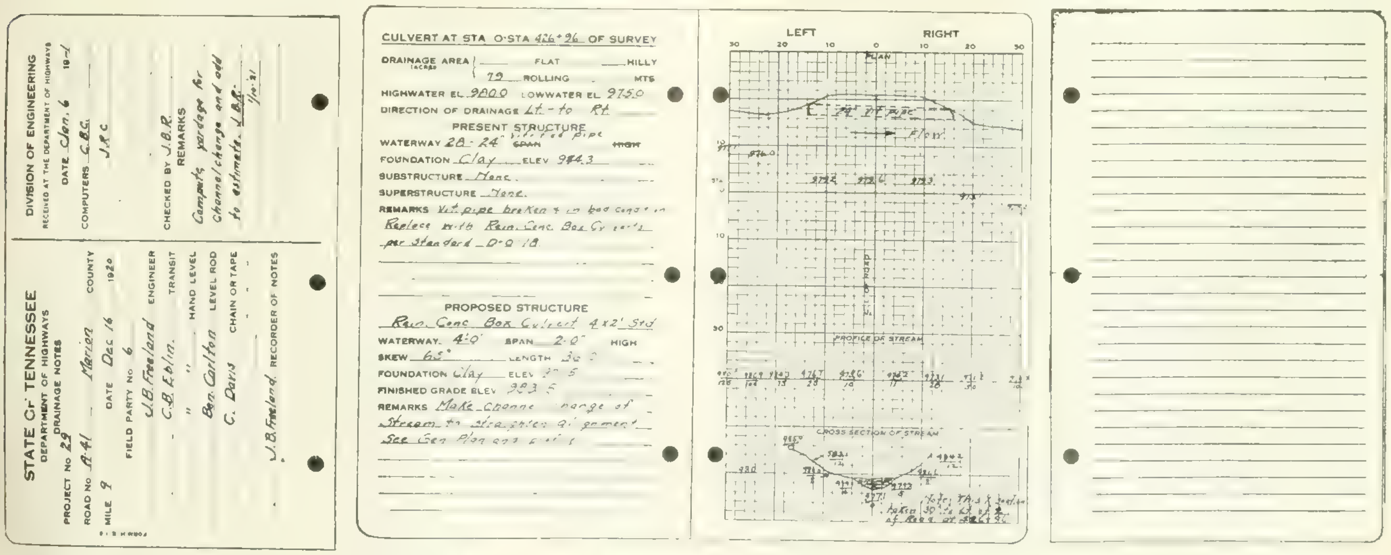
Standard Field Forms for Culvert Data

By O. H. HAMPSCH,

Office Engineer, Tennessee State Highway Department.

A standard field form for culvert data has been adopted by the Tennessee State Highway Department for use by field and resident engineers on road location work. The forms are used in duplicate with carbon, and are made to fit standard loose leaf folders.

One page of the sheet is devoted to drainage data information, to the present structure and the proposed structure, while the page opposite is devoted to sketches of the road plan, elevations, profile of the stream and cross-section of the stream bed.


LEFT
RIGHT
30
20
10
0
10
20
30
PLAN
PROFILE OF STREAM
CROSS SECTION OF STREAM

DIVISION OF ENGINEERING
RECEIVED AT THE DEPARTMENT OF HIGHWAYS
DATE Jan. 6 19
COMPUTERS C.B.C.
J.R.C.
CHECKED BY J.B.R.
REMARKS
Compute yardage for channel change and add to estimate. J.B.C. 1/10/21

STATE OF TENNESSEE
DEPARTMENT OF HIGHWAYS
DRAINAGE NOTES
PROJECT No 29
ROAD No A-41 Marion COUNTY
MILE 9 DATE Dec 16 1920
FIELD PARTY No 6
J.B. Freeland ENGINEER
C.B. Eblin TRANSIT
" HAND LEVEL
Ben Carlton LEVEL ROD
C. Davis CHAIN OR TAPE
J.B. Freeland RECORDER OF NOTES

CULVERT AT STA O-STA 426+96 OF SURVEY
DRAINAGE AREA (ACRES) FLAT HILLY
79 ROLLING MTS
HIGHWATER EL 980.0 LOWWATER EL 975.0
DIRECTION OF DRAINAGE Lt. to Rt.
PRESENT STRUCTURE
WATERWAY 2 B - 24" vitrified pipe SPAN HIGH
FOUNDATION Clay ELEV 974.3
SUBSTRUCTURE None
SUPERSTRUCTURE None
REMARKS Vit. pipe broken + in bad cond. [illegible] Replace with Rein. Conc. Box Culverts per Standard D-O 18
PROPOSED STRUCTURE
Rein. Conc. Box Culvert 4x2' Std
WATERWAY 4.0' SPAN 2.0' HIGH
SKEW 65° LENGTH [illegible]
FOUNDATION Clay ELEV [illegible]
FINISHED GRADE ELEV 983.5
REMARKS Make channel change of Stream to straighten alignment. See Gen Plan [illegible]

The Four Sheets of the Standard Field Form for Culvert Data.

By using these forms there is little excuse for the field engineer forwarding insufficient information to the office as had theretofore been the case. The forms also give the office engineer a clear conception of the plan and arrangement of the present structure so that he may intelligently design or estimate the proposed structure needed.

As these notes are received in the office they are dated, computed and checked, each engineer initialing the work he has done, or for what he is held responsible, while the duplicate is held by the field engineer as a record for further use. The advantage found in using a standard form as devised is that considerable time is saved in the field work by filling in the blanks with the necessary data, and that this form covers all required information necessary to the office when properly filled in, and eliminates any superfluous data being rendered by the field engineer.

Iowa Counties Own $1,065,000 Worth of Road and Bridge Building Equipment.—Reports of county engineers to the Iowa State Highway Commission show that the 99 counties at the first of the year owned road and bridge building equipment and tools totaled in value, $1,065,000. The largest single item in point of value among this equipment was the tractor. There were 199 of these estimated to be worth $321,963. The next item was the blade graders of which there were 960 estimated to be worth $223,605. There were a total of 3,847 road drags valued at $52,351. These figures do not include the war department equipment apportioned to the various companies, title to which remains in the State Highway Commission.

Construction to Be Started at Once on Pennsylvania Highways.—The Pennsylvania State Highway Department has notified contractors holding road contracts to resume construction at once. The advanced season will give the contractors a two weeks' start over 1920. When the road builders were compelled to cease operations at the coming of cold weather last fall, 467 miles of thoroughfare under contract remained to be completed. Some of the contractors in the southern tier of counties were able to continue rough grading operations over the winter months, but in the more northern sections all work was stopped.

Over $28,000,000 Spent in 1920 for Bridge and Road Work in Iowa.—Iowa during 1920 expended $28,024,945 for road and bridge building on its 104,082 miles of highway. This figure is based on definite reports to the State Highway Commission. In addition it is estimated that 258 townships not reporting spent $952,000. Of the total expenditures $7,483,973 was on the 6,619 miles of the primary road system, $5,795,553 on the 10,552 miles of county roads, $4,977,204 on the 86,908 miles of township roads and $9,804,213 for bridges and culverts.

New Road Builders' Association.—Three hundred employes of the State Highway Commission of New Jersey have organized the State Highway Association, with Alex W. Muir, Trenton, N. J., Superintendent of Maintenance in the State Highway Department as President.

Annual Convention of American Association of Engineers.—The seventh annual convention of the American Association of Engineers will be held in Buffalo May 9 to 11. New officers for the ensuing year will be elected.

California Proposes to Tax Gasoline.—A bill is before the California Legislature providing for a tax of 1 ct. per gallon on gasoline distillate, and fuel oils used in motor vehicles.

Public Control of Industry

By HALBERT P. GILLETTE, Editor.

Political economists may be divided into three schools. (1) Individualistic, (2) Socialistic, and (3) Socio-individualistic.

The first school believes in a "laissez faire," or "let alone" policy of government. Their motto is, "That government is best that governs least."

The second school believes in communistic ownership of land and productive plants. Their motto might well be, "That government is best that governs most."

The third school believes in a policy that is midway between the extremes of individualism and socialism. Their motto might be, "That government is best that wisely controls industry without becoming itself the owner of industries."

The great English philosopher and father of the theory of evolution, Herbert Spencer, belonged to the individualistic school. He interpreted the history of society as being a progressive evolution from military and social bondage to industrial freedom.

The great English novelist, H. G. Wells, belongs to the socialistic school. His recently published Outline of History traces an evolution from almost unrestrained individual freedom to greater and greater social subordination. He sees in Caesar, Napoleon and Kaiser William the incarnation of unrestrained individual power. They, to him, are the lineal descendants of the "old man of the cave"—the ruthless masters of the tribal family. And he sees similar individualists as captains of our great industries today. All such, he maintains, are to be surely brought under social control.

To me it seems that both Spencer and Wells have seen the shield of truth, but that each has seen only one side of the shield. There has been evolution toward greater freedom for the masses coincident with less freedom for their leaders. Spencer's eyes were fixed upon the growing freedom of the average individual. Hence his doctrine of evolution toward individual freedom. Wells' eyes are fixed upon the growing restraint upon the freedom of the leaders. Hence his doctrine of evolution toward socialism.

I should have selected Karl Marx instead of Wells, as a figure to contrast with Spencer, had I not preferred to name a man better known to Americans, and one whose recent Outline of History is now being so widely read.

The unbiased student of social history will see both sides of the shield. On one side he will observe a progress toward greater freedom for the majority of individuals. On the other side, progress toward great social restraint of both political and industrial leaders. He will therefore become an extremist in neither direction. He will reason that an ideal government is one that neither leaves great industrial leaders free to profit without limit, nor permits employes to dictate all the terms of their employment. He will come finally to believe in the doctrine of public control of industry, but in a control that does not remove the incentives that now exist under unrestrained competition.

Evolution of Public Control in America. Within my own lifetime I have seen a marked increase in public control of industry. I use the word industry in its widest sense, to include all economic activities from which profits are derived.

At one time nearly all American banks were uncontrolled by the government. Now the converse is true, in so far as the control of accounting, auditing and publicity of assets and liabilities is concerned.

Fire and life insurance companies are very largely controlled by state governments, the main object being to protect policy holders and investors in their securities.

Railways are controlled by federal and state governments, both as to the character of service rendered and the prices charged for it.

Other public utilities (street railways, light, power and gas companies, private waterworks, irrigation companies, etc.), are similarly controlled in nearly every state in the Union.

The most recent evolution in the history of public control of industry in America is to be found in Kansas and New York. In Kansas there is now a Court of Industrial Relations that regulates wages and hours of service of employes of public utilities and mines. In New York there is a law that gives Municipal Court judges the power to regulate the rents charged for city apartments. The state of Indiana has been on the verge of classing coal mines with public utilities, and regulating the price of coal

All this in a country where the vote of the Socialist Party at the last national election was negligible. While the great nations of Europe have been drifting into socialism, the greatest industrial nation in the world has been evolving a political scheme quite different—a scheme of public control instead of public ownership of industries. My belief is that America has chosen the wiser plan.

I base this not only on the fact that in economic matters a middle course between extremes is almost always wisest, both in private and in public matters, but on the fact that America has led the entire world for 80 years in industrial progress and in the rise of "real income" for the average worker. I use the term "real income" to denote the purchasing power of the daily or monthly wage. Measured in the commodities that the daily wage would purchase the following was the relative commodity wage of the average worker in America:

Year.	Commodity wage.
1840	40
1860	50
1880	70
1900	90
1905	100
1920	100

The average daily wage measured in money was 36 in 1840 as compared with 100 in 1913 and more than 210 in 1920—a 6-fold increase in 80 years. The above wage table is not based on money wages, but on commodity wages; that is, the quantity of goods that a day's wage would buy; and this was 2½-fold as much in 1920 as in 1840. Nearly all this increase occurred between 1860 and 1905, during which 45-year period, the commodity wage (or real wage) doubled.

The data upon which I have based these conclusions are published by the U. S. Bureau of Labor and the U. S. Census.

Such a remarkable record of industrial progress has never been known before in the world. It can not be ignored by any conscientious advocate of socialism.

Dangers of Price Control by Monopolies.—Not all monopolists are selfish to such an extreme as to extort unreasonable prices. The old school of political economists based most of their theories on the assumption that selfishness controls all economic activity. I am sorry to say that this is not wide of the mark, but it is not a universal truth. There are many industrial leaders whose Christianity is stronger than their desire to become wealthy or powerful. Such a leader was the late Theodore N. Vail, the president of the great Bell Telephone System. He was the head of one of the greatest public utilities in the world, and one that approached as closely to being a monopoly as almost any that can be named. Yet his company, during his long term of management, averaged only 8 per cent annual net profit on the capital actually invested in it. The price for telephone service was steadily reduced, up to the time that the world war doubled all wages and prices. Theodore Vail was the ideal monopolist because he was a Christian, and he needed no public control of the profits that his company made.

Unfortunately, not all industrial monopolists follow his code of ethics, and public control of their prices becomes necessary. But I mention him in passing, lest it be assumed that monopoly and unreasonable prices necessarily are twins.

There are commercial monopolies, farmer monopolies and labor monopolies whom the public distrusts, and more of such monopolies are constantly springing up. I see no sure defense for the public save through public control of certain of their practices, and perhaps of their prices. As a consequence of the recent great drop in the prices of farm products, there are now being organized great agricultural selling associations whose object is to control prices. I feel only sympathy for the losses that farmers have recently suffered, but I feel as great a sympathy for the losses that they are likely to inflict upon the public if they succeed in regulating the prices of their products as well as certain fruit producing associations have succeeded in recent years. To me it seems inevitable that the American public will ultimately control the prices of all monopolistic associations whose object is price control. Nor do I look for a perma-

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Abstract of address to the Men's Forum of First Baptist Church, Evanston, Ill.

nent return to unrestricted competition as a means of price control. Unrestricted competition leads to periodic over production and disastrous fluctuation in prices.

Dangers of Public Control of Prices.—The history of public regulation of railway and other public utility rates is not one to arouse any enthusiasm. For 15 years federal and state governments' have been very active in fixing the prices charged for railway transportation, electricity, gas, water, telephone service, etc.; and it has been a period of steady decline of progress in the industries thus controlled. However, the reason for this decline is to be found not in public regulation so much as in the public regulators, who, as a rule, have been politicians seeking to win public approval by holding railway and utility rates down to a minimum barely short of confiscation. There have been notable exceptions, but the rule has been as stated.

Many state public service commissioners have been ambitious to become governors, others having lived an entire life of catering to public desires have been eager to continue pleasing the public. The public naturally prefers a lowering of rates to a raising of rates. What is more natural, therefore, than a general tendency for a public rate making body to keep rates down to a minimum? Investors have been gradually coming to see that, in the long run, the profits of railway and utility companies are too small to be attractive. Hence the slackening of development in those fields, in spite of the vigorous efforts made to attract capital into them, and in spite of a natural leaning of investors toward investments in monopolistic enterprises.

To overcome this objection is not at all difficult in theory, however difficult it may be in practice. What is particularly needed is greater freedom of public service commissioners and judges from fear of offending the public if they do their duty. Also there is needed greater deference to the opinions of experts in engineering and business economics. No man who is to judge the fairness of prices charged for public service should be elected to office. He should be appointed, and his appointment should be for life, after having passed a civil service examination. He should be paid a very liberal salary, one high enough to attract and hold the best minds. The solution of the problem is simple. The trouble lies in putting it into effect in a country that still believes in the present crude methods of selecting public servants. A judge should never have the slightest personal interest in the results of his decisions. This principle is self-evident, yet it is violated outrageously by our present methods of electing and appointing men to judicial and quasi-judicial positions. The public service commissioners in most of our states hold office only for short terms, and are frequently the footballs of politics, or are frequently politicians themselves. No system of public control of industry can succeed so long as such a condition exists. It were better to revert to a state of uncontrolled monopoly than to persist in this sort of control of public utilities.

But we have had 15 years' experience in the regulation of public utilities, and it has not been a complete failure. There are a few states where courageous and intelligent state commissioners have not crushed the life out of public utilities, and have, in fact, done more good than harm by regulating rates. These instances demonstrate the possibility of effective and fair public control of prices charged by monopolistic industries.

The Nature of Economic Problems.—Every economic problem resolves, in the final analysis, into a quantitative problem. Mere qualitative reasoning will not solve it. There must be numerical or quantitative reasoning. But the average voter does not know that this is true. He vainly hopes to secure a correct answer to any economic question by debate, when, were he more scientific, he would realize that the correct answer is securable only by the aid of statistics. Is municipal ownership preferable to private ownership of street railways? The ordinary method of answering such a question is to set up two columns of reasons, one for, the other against, and at the end to guess whether the pros or the cons predominate. But such a method, common as it is, is illogical. The correct method is to study the dollars and cents results of public and private ownership of street railways, and from the statistics demonstrate which is economically preferable.

This sort of study is obviously beyond the capacity of the average voter, even if he had the time to devote to it. It involves expert knowledge. Hence nearly all economic problems ultimately must be solved by men expert in the fields to which they relate. But we Americans are still too ignorant to see the full truth of this generalization.

The data needed in solving many economic problems are incomplete, and, in many cases, can be secured only by scientifically conducted experiments. But the average politician is not scientific, and, in the absence of data, either manufactures them to suit his purpose, or seeks to answer the economic question without any statistical facts. It is the essence of politics as it now exists to arouse argument, and still more argument, because where quantitative facts are absent or insufficient, proof of a contention is impossible.

America has yet to emerge from the debating school era and enter the experimental laboratory era of government.

Concrete Paved Railroad Crossings in Wayne County, Michigan

Through co-operation with various railroad companies the county road commissioners of Wayne County, Michigan, are gradually improving all the grade crossings in the county highway system. According to a paper presented at the recent convention of the American Road Builders Association by Edward N. Hines, chairman of the commissions, the following methods have been used in this work:

Under light traffic railroads, street car tracks and sidings, excavation has been made under the ties to a depth of 1 ft. below the bottom tie and filled in with a 1-ft. slab of concrete. Then new ties are placed and new deep rails spiked on. The job is completed by pouring concrete between the ties and over the ties to the top of rail joining with our concrete pavement on either side and striking off level with the top of rail. Flange-way is provided either by allowing the car wheels to form their own flange-way or by placing a rail on its side against the inside of the main rail.

One railroad has allowed an experiment with one of its main double-track lines by putting in a pre-molded concrete slab crossing. These slabs are approximately 2 ft. by 6 ft. long, with a depth the same as the depth of rail. They are built at Wayne in the commissioners' tile yard and hauled out to the crossing and laid in place of the common plank. With this type of crossing it is possible for the section crew of the railroad to remove the slab, ballast up the tracks and replace it.

Another type of crossing which has been used is similar to the first mentioned except that the surface has been filled in with special granite blocks along the inner side of the rail, which provides a flange-way.

California Highway Commission Prefer Contract Work to Day Labor.—In its recently issued second biennial report covering the period ending Dec. 31, last, the California State Highway Commission has the following to say regarding day labor and contract work:

In re-establishing active highway construction, the California Highway Commission will pursue its definite policy of doing work by contract rather than by day labor work, wherever possible. The reason for this policy is obvious. The state highway organization is capable of doing twice the volume of work by contract that it could do under day labor because of the enormous detail imposed by the latter method of operating. Therefore, the Commission never undertakes by day labor a job large enough to warrant advertising for contract, except under exceptional circumstances or where a fair bid is not obtained. During the early period of highway construction fully 80 per cent of all work was done by contract. As war conditions developed, the uncertainty in contracting influenced contractors to play safe, and bids were found to be excessively high. The result was that the percentage of day labor work automatically increased until recently the percentage volume of contract to day labor work reached about a 50-50 basis. With resumption of active construction under the more normal conditions that seem to be returning, the Commission hopes to do less and less day labor work, and more and more contract work. In this connection attention might be called to the fact that the ability of the Commission to undertake its own work has had a very noticeable influence in keeping bids within reasonable and fair limits.

The Motor Truck Impact Tests of U. S. Bureau of Public Roads

Impact depends largely upon the kind and condition of the tire.

Thin or worn rubber tires, even though they be very wide, produce very high impact forces.

Pneumatic tires offer the greatest influence in reducing impact forces, and with their use the impact increases only very slightly with the speed of the truck.

Cushion tires; that is, tires having a degree of softness and deflection between solids and pneumatics, offer corresponding advantages in reducing impact.

Impact increases with the speed of the truck, but it can not be said to increase according to any constant ratio or power of the speed.

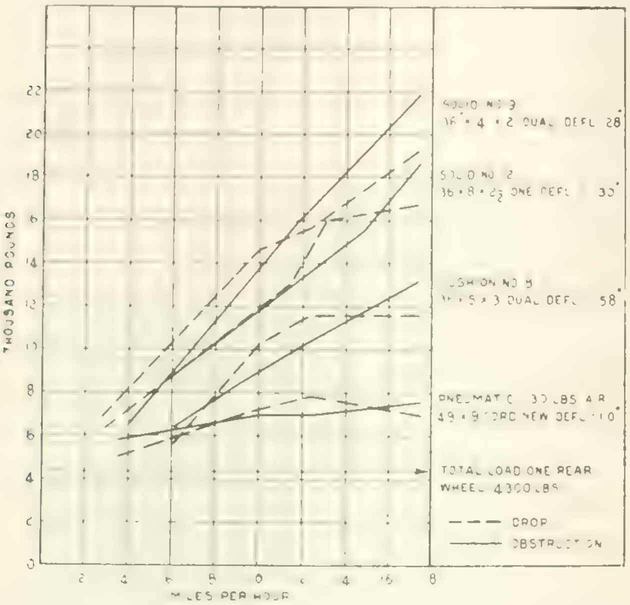


Fig. 1—Comparison of Tires. (Truck, 2-Ton A; Load, 2 Tons; Unsprung Weight (mg), 1,000 Lb.)

Although heavy unsprung weight may give higher impact than lighter unsprung weight, it can not be said that this is the major controlling factor.

The relatively destructive effect produced by light-weight, high-speed trucks and heavy, slow-moving trucks has not been determined by these tests. They do, however, indicate that equal impact may be obtained under some conditions.

Impact may be as high as 7 times the static load on one rear wheel when a solid-tire truck strikes a 1-in. obstruction at 16 miles per hour, an average value being about 4 times. For pneumatic tires the maximum impact value is probably not more than 1¾ times the load at one rear wheel, and an average value is not more than 1¼ times the load.

The above are the high points of a report of the tests now being made by the U. S. Bureau of Public Roads to determine the effect of motor truck impact on roads, as given by Mr. Earl B. Smith, Senior Assistant Testing Engineer of the Bureau, in the March issue of Public Roads, the official publication of the Bureau. Further extracts from Mr. Smith's paper follow.

The tests are planned to show the influence of only the important factors upon the value of the impact force. Not all possible factors are considered, only those having a definite and direct influence and which are more or less easily controlled in the operation of a motor truck, or which may be controlled in the design and equipment.

The speed of the truck is considered to be one of the most important factors. It is the factor which is most spoken of in connection with the operation of a truck, and the one factor against which there are aimed more traffic rules and laws than any other. The determination of its effect upon the value of the impact force is very important. For this reason speed values, in miles per hour, have been made the independent variable in most of the tests.

Trucks of different weights and capacities, have been used in the tests. Some of these trucks have comparatively heavy unsprung parts and some have light unsprung parts. The effect of this factor was especially studied in the tests upon two trucks of the same capacity under different loadings and speeds, each truck being equipped with the same set of tires.

Tire equipment was considered to be a very important factor. As far as possible, each truck was tested, at different speeds and loadings, with several kinds and conditions of tires.

To get a definite idea of the effect of the height of fall, or of the height of an obstruction or irregularity in a road surface, this factor was used as one of the variables in most of the tests.

A few of the important features and indications based on the experimental results obtained during the conduct of the test are shown in Figs. 1 to 6 inclusive.

Tire Equipment and Impact.—Figure 1 shows an important comparison of the effect of the tire equipment upon the value of the impact. The truck used in this comparison was of 2-ton capacity, carrying a 2-ton load. Four different tires were used and a complete series of tests was run with each, using in each case the speed as the independent variable. The comparison is shown with both the drop and the obstruction test. To draw attention to the obstruction test only, it is noticed that the impact value (the ordinate) shows a considerable change with only a slight change in the tire deflection. The impact value, with all conditions the same except the tire, is the greatest for the solid rubber tires and the smallest for the pneumatic tire, the cushion tire giving an intermediate value. At low speed the difference is not so great. At a speed of 17½ miles per hour the pneumatic tire gives an impact value of only 1.75 times the rear wheel pressure on the road surface, the cushion tire over three times, and the solids 4.3 to 5.1 times. In this particular case, the cushion tire gives an impact value of 63 per cent of the solid tire average, and the pneumatic only 36 per cent. It should also be noticed that for the pneumatic tire the impact value increases only very slightly with the increase of speed.

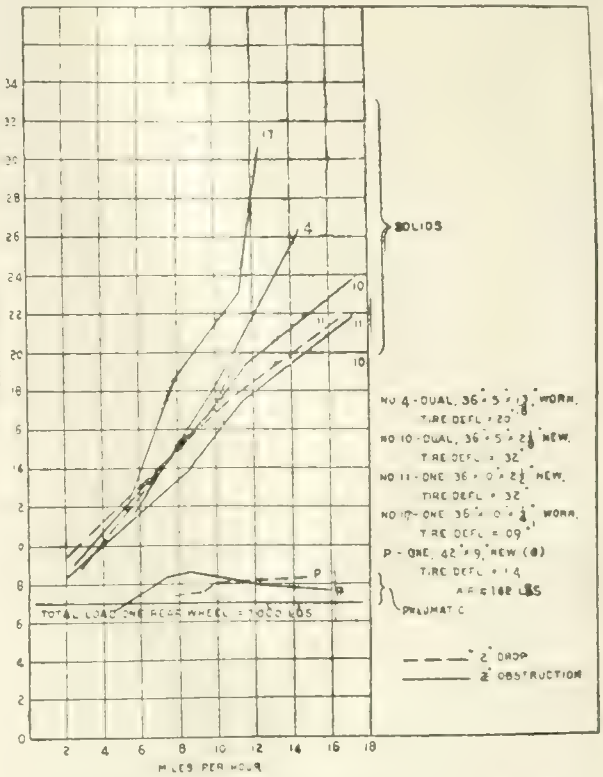


Fig. 2—Comparison of Tires. (Truck, 3½-Ton P; Load, 4½ Tons; Unsprung Weight (mg), 1,300 Lb.)

Figure 2 shows also a comparison of the effect of tire equipment. The truck used in this case was of 3½-ton capacity, loaded with 4½ tons, the unsprung weight being equal to 1,300 lb. The total load at one rear wheel was 7,000 lb. Here, it should be noticed that with pneumatic tire equipment the impact force was only 15 per cent greater than the actual wheel load. The four different solid tires which were used in this series show very clearly the effect of the condition of the tire. Tire No. 17 gave some very high impact values even at 12 miles per hour. This tire was badly worn, having a thickness of only one-fourth inch above the rim. The other solid tires give impact values somewhat in proportion to their deflection or condition. The results as shown by tires Nos. 10 and 11 indicate the usual impact values that may be expected with good solid tire equipment, while the results shown by the use of tires Nos. 4 and 17 show the increase or extreme values that may be expected from the same truck when the tires are in a badly worn condition.

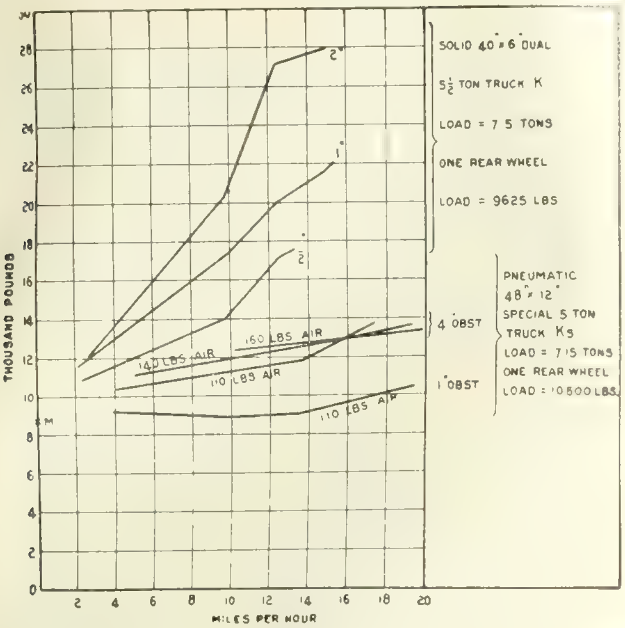


Fig. 3—Comparison of Solid and Pneumatic Tires; Two Trucks Approximately the Same.

Effects of Solid and Pneumatic Tires.—Figure 3 is also a comparison between the effects of solid and pneumatic tires. The truck used in this case was of 5½-ton capacity, loaded with 7½ tons. This figure is intended to show the very great cushioning effect of pneumatic tires in comparison with solid tires. In this case a 4-in. obstruction was used during the test with the pneumatic tires, and the resulting effect was very much less than when using a solid tire on ½-in., or 1-in., or 2-in. obstruction. The figure also shows the effect of the air pressure in the pneumatic tires upon the value of the impact force.

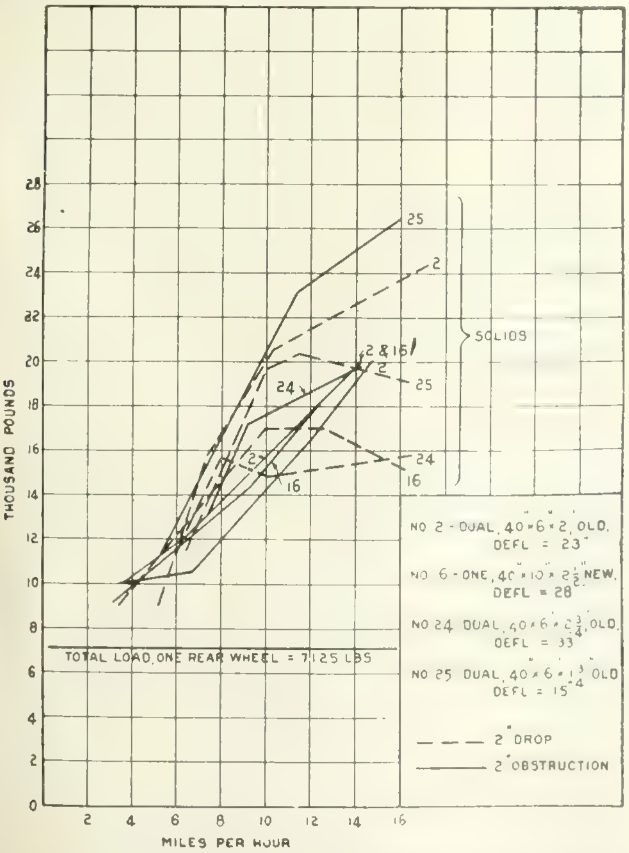


Fig. 4—Comparison of Tires. Truck, 5-Ton K: Load, 5 Tons; Unsprung Weight (mg), 1,300 Lb.

Figure 4 shows also a comparison of tires. This shows that in general the magnitude of the impact force is dependent upon the condition and deflection of the tire. It shows, as did Fig. 8, the wide variation in impact values that may be expected from the same truck equipped with tires of different conditions

Comparison Between Trucks.—Figure 5 shows a comparison between trucks. Two 5½-ton trucks were used in this case and each was loaded so that the total rear wheel load was the same in each case. Truck A had an unsprung weight of 1,950 lb. and truck K had an unsprung weight of 1,300 lb. Both trucks were equipped with the same set of tires. The purpose of this comparison is to show the effect of unsprung weight upon the impact value. It is very clear that the truck having the lighter unsprung weight produced the smaller impact values under the conditions of this test.

Possible Impact Values for Trucks of Different Capacities.—The purpose of Fig. 6 is to show the possible impact values which may be obtained by using trucks of different capacities. It is clear that the light truck, W, if run at a sufficient speed, may give impact values as high as a heavy truck, when run at the ordinary truck speed of 8 to 10 miles per hour. These impact values were all obtained from a 2-in. obstruction. This figure shows that it can not be said that a heavy truck always gives the highest impact values, without stating several qualifying conditions, especially the condition of speed and of tire equipment. This statement refers to impacts only. It should be noted in particular that a light truck running at high speed will produce large impacts only occasionally and never very heavy load pressures; while a heavy truck will produce in addition to impacts a continuous heavy pressure on the road surface.

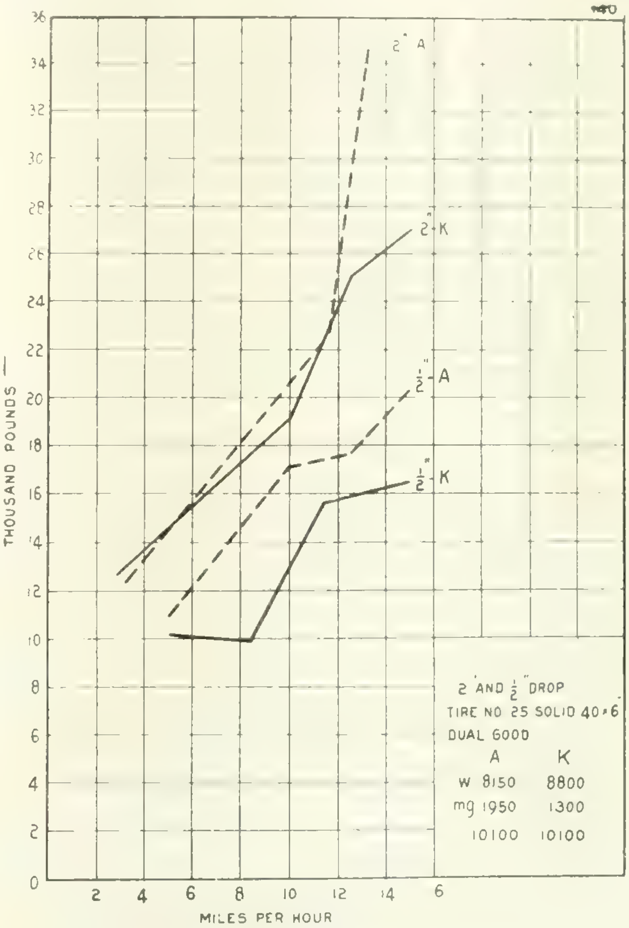


Fig. 5—Comparison of Trucks Vs. Speed.

Summary of Indications.—The results presented must not be considered as final. The investigation has not been completed, and will continue under different conditions for some time. It is not the intention in this paper to state final conclusions or to deduce final laws and comparisons. It is, however, thought desirable to state briefly some of the indications toward which these results may point.

The impact value depends very largely upon the tire equipment. The condition of the tire—that is, whether it is new or badly worn—determines the amount of cushioning effect it may offer. The deflection of the tire depends upon its depth and quality, and any condition of the tire which adds to its deflection will, of course, serve to reduce the impact. The actual shape and construction of the tire seem to have considerable influence upon its cushioning effect. No account, however, has been taken of the power-consuming factor of any particular type or shape of tire.

So far as they have been tested, cushion tires seem to offer a decided advantage in reducing the impact. In this connection it should be stated that the name "cushion" on a tire does not necessarily make it such a tire. Some definitions and deflection requirements should be adopted for the classification of tires. Certainly a tire which does not have at least a deflection value of 40 per cent to 50 per cent of the deflection of a pneumatic tire under the same capacity load should not be classed as a cushion tire.

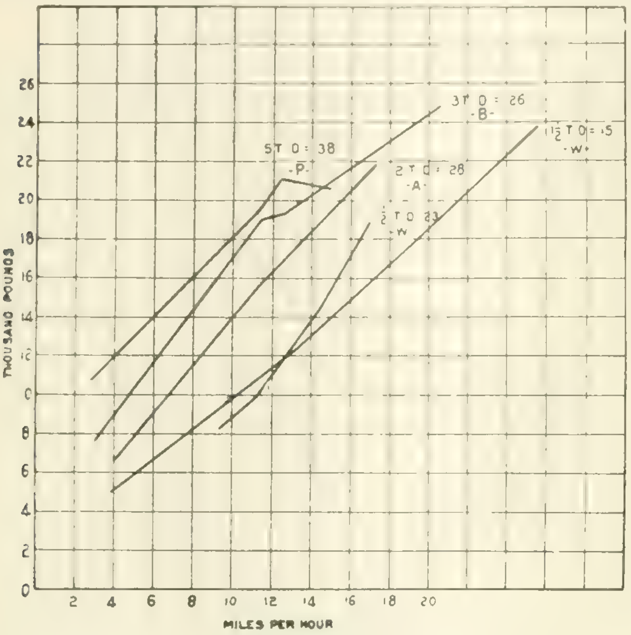


Fig. 6—Comparison of Trucks. Tire Deflections Indicated. All 2-In. Obstructions.

Pneumatic tires, as might be expected, show a very great influence in reducing impact values, and the impact produced with such equipment seems to increase only very slightly with the speed.

Considering the effect only upon the impact, the width of the tires, or the load per inch of tire width has very little controlling influence. The deflection of the tire is the main factor and this is controlled only slightly by its width. A decrease in tire width increases the load per square inch of tire, which in turn causes a slightly greater tire deflection. This, then, should tend to slightly decrease the impact. It will thus be seen that a large tire width does not tend to decrease the impact, but rather to increase it. It is a fact that a very wide but thin solid tire will give much higher impact forces than a narrow thick one. In so far as the unit load on the road surface is concerned, this must be considered from an entirely different viewpoint.

The speed of the truck has an important influence upon the value of the impact force, but it is a somewhat complex relation. It is not a simple arithmetical ratio, nor can it be expressed simply as a certain power of the speed ratio. When striking an obstruction or irregularity, the curve showing the impact values in relation to speed is approximately a straight line. But the equation of this curve depends upon the characteristics of the truck, the height of the obstruction, and the deflection of the tire, as well as the speed. For approximate comparisons it may be stated that the impact increases with the increase of speed.

10 to 100 per cent for solid tires;
10 to 75 per cent for cushion tires;
and 0 to 10 per cent for pneumatic tires.

An average of any of these limiting percentages must not be used, as the performance of any truck is too variable, and the relation of the other controlling factors can not be predicted.

When dropping from one level to another the speed affects the impact value somewhat according to the percentage variations, given in the preceding paragraph, up to the point of a critical speed of 9 to 12 miles per hour. Beyond the point of critical speed at which the wheel falls freely there should be no increase in impact value.

Although heavy unsprung weights may give higher impact values than lighter unsprung weights, it can not be said that this is the major controlling factor. With all other conditions remaining constant this may be true. But other controlling factors, such as tire equipment, spring stiffness, load carried, and speed, may have a greater influence and overcome any difference due to the unsprung weights.

It is easily possible to so operate a light-weight truck under certain load conditions that it will produce as high impact values as a heavy truck under certain conditions. Much remains to be learned, however, as to the relative destructive effects of light-weight, fast-running vehicles, and slow-moving heavy trucks.

Cost of Motor Truck Haulage in Road Construction in Brant County, Ontario

The following data on motor truck operation in 1920 are abstracted from a paper presented by A. M. Jackson, Engineer of Brant County, Ontario, at the recent conference of the County Road Superintendents and Engineers of Ontario:

The 3-ton truck was operated with a trailer, the combined pay load being 9 tons. The figures given below are taken from the actual returns to the Ontario Department of Public Highways for the cost of equipment and repairs, and from the drivers' weekly reports, accompanied by vouchers for gas, oil and grease:

Investment:	
Truck and body	$ 8,110.95
Trailer	2,610.00
Total	$10,720.95
Fixed charges:	
Average amount of interest per annum at 7 per cent for 5 years, figuring on 20 per cent depreciation each year on truck, without tires	$ 330.08
Average amount of interest per annum at 7 per cent for 8 years, figuring on 12 per cent depreciation each year on trailer, without tires	100.57
Depreciation, 20 per cent of $8,110.95, less $252 (cost of tires)	1,571.79
Depreciation, 12 per cent of $2,610, less $252 (cost of tires)	326.25
License	1.00
Annual overhaul	201.11
Total of fixed charges	$ 2,530.80
Days operated for season	160
Fixed charges per day	15.82
Variable charges:	
Gasoline (= miles per day times gallons times cost)	$ 7.87
Oil and grease (= miles per day times quarts times cost)	2.94
Tires on truck (5,000 miles)	2.27
Tires on trailer (figured at 4 times the life of truck tires)	.57
Driver	6.00
Total variable charge per day	$ 35.47
Average cost per ton-mile over entire season	$0.188

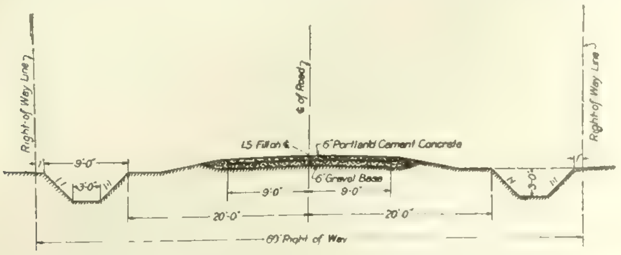
Cost of Logging Roads in Montana.—In order that the State Highway Department of Montana might have more definite and workable knowledge of the condition of its main state highways not scheduled for immediate improvement a thorough investigation, covering 3,992.5 miles of primary highways, was made during the past summer. The information required relates to grade and alignment, drainage, necessity for surfacing and availability of surface materials and other features essential to a proper knowledge of the state road system. This road logging, according to the recently issued second biennial report of the State Highway Commission, cost $2,806 or, for the 3,992.5 miles logged, 70.3 ct. per mile. The data acquired are being tabulated for use by the department during the coming season; and it is intended to make the data available also to county officials for their use in connection with the maintenance and repair of unimproved state highways within the counties.

Keeping Traffic on Its Own Side of Road.—In the interest of safety the Road Commissioners of Wayne County, Michigan, are painting white dividing line on the concrete roads. They find that the line has a decided tendency to keep traffic on its own side of the road.

Special Highway Construction Through Rice Fields

The development of rice growing in California during the last 7 or 8 years has very materially increased the difficulties and expense of highway construction through these sections. In the cultivation of rice the only time there is no water on the land is the period of not more than a month preceding planting and the period from the time the field dries in the fall till the rains set in. An average of over 8 ft. of water is required over the entire field for a season's irrigation.

In the early stages of rice cultivation in California insufficient attention was given to the drainage feature with the result that the land soon became waterlogged. This early lack of drainage ditches likewise soon caused a serious condition of the roads over which the rice must be hauled to market as well as being the cause of the complete failure of many main traveled highways which had been constructed prior to the advent of the rice grower. Practically the only drainage in the early stages was along the natural runoff channels and no drainage ditches were provided parallel with the highways.



Typical Section of State Highway Through Rice Fields in Butte County, California.

Several miles of a section of state highway in Glenn County between the southerly boundary and Willows constructed in 1914 and 1915 before an extensive acreage had been planted to rice, due partly to the saturated subgrade and partly to the alkali in the drainage water, have failed completely in the last two years. A special method of construction was employed in building a section of state highway through rice fields in Butte County, California. The following description is taken from the recently issued 2nd biennial report of the California State Highway Commission. Bids were advertised to be opened on Nov. 26, 1917, on a section of state highway in Butte County between Biggs and Nelson. Due probably to the fact that a portion of the section is through a rice country and also due to the unsettled labor conditions no bids were received. Bids were again called for June 24, 1918, but again none were received.

This section was the only unpaved section on the main line along the east side of the Sacramento Valley between Sacramento and Chico and, as the prospects of securing any bids were unfavorable, it was finally decided to proceed with the paving by day labor.

As stated above, a portion of the section in the vicinity of Richvale is through a rice district. When grading was started on this portion in the latter part of 1918 it was found to be impossible to handle the water soaked adobe with teams and fresnos.

In the meantime experience in Glenn County had shown that unless adequate drainage ditches were provided and the concrete base increased in thickness and reinforced, early failure would result. In Butte County a black clay adobe formation overlies the hardpan for an average thickness of 3 ft. When the water is turned off the rice fields at harvest time the season is too late to permit the adobe to dry out sufficiently so that teams can be used in grading the soft mud.

Arrangements were therefore made to rent a ditching outfit and to dig a ditch on each side of the highway, 3 ft. deep and 3 ft. wide on the bottom with 1:1 slopes, making a top width of 9 ft. The dirt was deposited in the center of the roadway with a 3-ft. berm between the toe of the roadway slope and the edge of the ditch.

The ditcher was first operated on one side of the road, cutting the ditch and distributing the material towards the center of the roadway. The bucket of the machine had a swing of about 24 ft. and was equipped as a drag line, cutting towards the machine. The ditcher was moved on skids by its own power exerted on a cable attached to a deadman.

Having cut one side the ditcher was turned around and cut back on the other side. As soon as the material thrown out of the ditches into the roadway had dried out sufficiently, fresno and grader teams were put on to make and shape the grade.

When possible the drainage ditches dug by the ditcher were led into main drainage ditches excavated by the rice companies or landowners. In some cases, however, outlet ditches have not yet been dug by the property owners and the seepage water is standing in the borrow pits along the highway. Strong efforts are being made, however, to provide proper outlets at all points so that there will be no standing water along the highway.

The ditching with the machine cost approximately 40 ct. per cubic yard of dirt handled. On the top of the grade thus built there was spread 6 in. of gravel 22 ft. wide. A Portland cement 1:2:4 mixture, concrete base 18 ft. wide by 6 in. thick reinforced with ⅝-in. square rods spaced 18 in. apart and with a ⅝-in. rod along each edge was then constructed on top of the gravel foundation. The gravel worked into the comparatively soft adobe subgrade to a certain extent, thus providing a hard and firm foundation for the pavement base. No special difficulties were encountered either in the ditching or in the construction of the pavement. Due to labor and car shortage, however, the progress of work was hampered to such an extent that, though started in the fall of 1918, the pavement was not completed until the fall of 1920.

The total length of the section is 12.5 miles, but the southerly 6 miles are along an old road where the soil conditions are such that no special construction was considered to be necessary.

The northerly 6.5 miles, however, are practically entirely through an adobe formation which has been planted to rice, and the special construction described above was adopted throughout on this portion of the section. These 6.5 miles cost approximately $341,000, or at the rate of $52,500 per mile.

Asphalt Macadam Base for Relaid Granite Blocks

When the Department of Public Works of Providence, Rhode Island, had to relay a considerable yardage of old granite block pavement last year, the engineers decided to use an asphalt macadam base under the relaid blocks.

The old granite block pavement was laid originally partly on a 6-in. cement-concrete foundation and partly on a rolled broken stone base. Much of the pavement had settled in places after undergoing considerable traffic, and it was found necessary last year to relay the block.

The first step was to take up and clean the old blocks thoroughly, no recutting being necessary. The sub-base was of gravel, varying in thickness up to 8½ in. This sub-base was rolled thoroughly, and on top of it was placed 2-in. trap rock which was rolled to an average depth of 3 in. Smaller sized trap rock was spread and rolled to fill the larger voids.

This stone was then given a penetration treatment of No. 96 Texaco asphalt, using about 1½ to 1¾ gal. per square yard. Stone chips were then spread and the base was rolled. Following this a sand cushion 1 in. or more in depth was spread on the asphalt macadam base, and on this cushion the granite blocks were relaid.

After the blocks were laid, and a small amount of stone chips had been swept into the interstices, the joints were filled with Texaco asphalt. Sufficient asphalt was spread so as to slightly flood the surface of the blocks for about one-third their area.

After the Texaco asphalt filler had been applied, the surface was covered with clean stone chips and rolled, after which the street was opened to traffic.

New Jersey Gives Up Use of Convicts on State Highways.—New Jersey, according to the Service Bulletin of the Iowa Highway Commission, has definitely abandoned convict labor on the state highway because of dissatisfaction of the results obtained. The state highway engineer, T. J. Wasser, has reported that the work of the convicts has been characterized by a marked degree of inefficiency and that the cost of maintaining the camps has been excessive in comparison with the work accomplished.

Results of a Study of the State Highway System of California of U.S. Bureau of Public Roads

A comprehensive study of the work of the California State Highway Commission has been made by the U. S. Bureau of Public Roads. The results of this investigation of the California State highway system are given in a report of the Bureau made public early in March. The report, with 11 appendices, contains 58,000 words of text and includes numerous tables and 115 maps and diagrams. It is divided into three parts which cover the subjects, respectively, Data, Discussion and Conclusions. Accompanying the report is a photographic supplement containing 400 photographs of road types, concrete cores, soil samples, bridges and structures, etc.

The field work on the investigation was begun July 8, 1920, under the direction of Dr. L. I. Hewes. The field studies and the preparation of the report were carried forward under the immediate direction of Dr. Hewes and T. Warren Allen, General Inspectors of the Bureau of Public Roads.

In his preface to the report Mr. Thomas H. MacDonald, Chief of the Bureau of Public Roads, says:

> An adequate review of the results which have been secured by the development of any system of state highways must follow today an uncharted course. The essentials and non-essentials of such a task have not yet been sufficiently classified to avoid the gathering, on one hand, of material which modifies only slightly the final conclusions, or, on the other, to insure that all vital data and information are secured.
>
> The California study is the most comprehensive study of results obtained through the development of a state highway system that has yet been undertaken. The work of this study has followed two principal lines: one that includes those questions that are engineering in character, and the other those that are economic in character. These two groups of questions are so inter-related and so inter-dependent that they cannot be separated. All road improvement is a means to an end—improved transportation facilities. The proper development of such facilities ought to be based on both the engineering and economic considerations involved. But the practical application of these considerations is always modified by the attitude of the public.
>
> For the purpose of this study, the principal operation was to classify all the pavement laid. This classification covered 1,262 miles from which a complete record of condition of all concrete pavement for each one-tenth mile resulted, and is supported by 7,500 consecutive photographs filed in the Bureau. It is recorded completely by diagram. Associated with this classification there were drilled 638 cores through the pavement at intervals on 800 miles of the highway between Red Bluff and San Diego; 481 of these cores were tested and all were carefully examined and tested. A large number have been photographed for this report.
>
> Twelve special, intensive studies of failed portions of the road surface resulted in a great volume of data which can only be summarized in the report, but which clearly establish in practically every instance the nature and cause of the defective pavement.
>
> In connection with the many selected special studies, soil moisture determinations were made for cross sections of the road by borings at close intervals. Tests for moisture content, moisture equivalent and for shrinkage were made at the laboratory of the University of California.
>
> A complete classification of the sub-grade soil under all the pavement on the state highway system was made by soil experts and plotted on the pavement condition diagrams. Below each concrete core samples of soil were also removed and tested.
>
> A state-wide traffic census was taken at 103 stations for an equivalent 16-hour weekday, and many Sunday and supplementary counts were also taken. This traffic record revealed the amount and character of travel for the summer interval on the state highways. It has resulted in a set of traffic [illegible] from which the total annual duty of the California highway system has been estimated, and also the corresponding revenue, or the operating income to the community.
>
> Supporting the traffic count, extensive field studies were made [illegible] agricultural areas for [illegible] agricultural [illegible] peak load in tons and the [illegible] for these crops was determined. This study [illegible] the main valleys of the state.
>
> During the progress of field investigation there was carried on at Sacramento a complete audit and analysis of all the books of the State Highway Commission office. This work resulted in a satisfactory and complete distribution of all costs of surveying, construction, engineering and maintenance, and produced summaries that account for practically every dollar made available for the use of the commission.
>
> Painstaking efforts have been made to secure all the data necessary to present the conclusions impartially and uncolored. There is much of value in the record to be made available after more research.
>
> Within the past five years an unprecedented demand has been made upon the highway administrator and highway engineers to produce a large mileage of economical and serviceable highways. The extent to which he has produced this combined result is the true standard of measurement of his achievement.
>
> Let the present traffic service rendered by the state highways of California, conservatively, we believe, estimated at 100,000,000 vehicle miles per year be multiplied by any reasonable unit rate to indicate the present annual returns to the people on the total investment to date of about $42,000,000.
>
> Now turn to one paragraph from the report selected as the most vital to be repeated here:
>
> "The financial administration has been scrupulously honest and careful and the administrative and engineering costs have not been excessive, nor have final costs much exceeded the engineer's estimates."
>
> There should be no hesitation in going forward with confidence.

Abstracts of three sections of the report covering the subjects of "Data," "Discussions" and "Conclusions," follow.

Data.

Of the total system laid out under the three bond issues of 5,360 miles, there have been graded and completely paved 1,345.4 miles and 377.1 miles graded and not paved; 319.4 miles were in process of grading and not to be paved, and 206.8 miles were still in process of paving with Portland cement concrete, all on July 1, 1920. Of the paving 765 miles is Portland cement concrete unsurfaced, and 480.7 miles is surfaced ⅜-in. with bituminous material and pebbles; 53.9 miles of concrete have been surfaced with Topeka and 4.2 miles with Willite. There are 33.8 miles of oiled macadam. Total actually constructed to date is 1,930 miles.

Classification of the Concrete Pavement.—The classification of the existing condition of the concrete pavement in the state for each one-tenth mile was made by the following six classes:

(A) A pavement in which the plainly visible transverse cracks do not exceed the normal number expected of a pavement constructed without expansion joints, and which has no plainly visible longitudinal cracks.

(B) A pavement having more than the normal number of plainly visible transverse cracks or with some "crow-foot" cracks at the edges, or with both.

(C) A pavement similar to classes A and B and with one plainly visible longitudinal crack or with a considerable number of "crow-foot" cracks.

(D) A pavement so cracked transversely and longitudinally that numerous slabs are formed of less area than in class C but that do not average less than about 50 sq. ft.

(E) A pavement in which the plainly visible transverse and longitudinal cracks are so numerous that it is broken into slabs having areas less than about 50 sq. ft. but in which no general disintegration appears.

(F) A pavement badly broken and with disintegrated portions.

The classification result is given by Table I which shows that 12.5 per cent of the pavement on July 1, 1920, was found to be in classes D, E, and F and the balance or 87.5 per cent in classes A, B and C.

Determination of Conditions of Concrete by Sample Cores.—For the purpose of determining the condition of the concrete actually in place, sample cores were drilled from approximately 800 miles of the pavement. In all, 638 4½-in. diameter cores were drilled. There were 187 cores drilled with the chilled shot type drill and the remainder with the diamond drill.

[illegible] SHOWING ALL CLASSIFIED CONCRETE PAVEMENT BUILT BY THE STATE. (SURFACED AND UNSURFACED.)

[illegible]	1913		[illegible]		[illegible]		1916		1917		1918		1919		1920		Totals	
	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.	Miles.	%.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6.65	11.3	37.54	30.0	53.91	32.6	33.24	42.9	418.23	33.1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26.29	44.4	49.50	39.6	66.78	40.4	37.32	48.2	475.46	37.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15.28	25.8	24.37	19.5	23.90	14.4	4.15	5.4	211.40	16.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.66	14.6	10.24	8.2	12.20	7.4	1.60	2.1	84.44	6.7
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.29	3.9	3.29	2.66	8.23	5.0	1.00	1.3	30.01	2.4
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.60	...	.05	.04	.25	0.2	.10	0.1	42.17	3.4
[illegible]	[illegible]	100	[illegible]	100	[illegible]	100	[illegible]	100	59.17	100	121.99	100	165.27	100	77.41	100	1,261.71	100
[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		4.7		[illegible]		13.1		6.1		100	

The results of tests showed that the cores varied considerably in respect to the maximum size of coarse aggregate, its distribution, the coarseness of the sand and the grading of the sand. The depth of concrete varied considerably, but in general ran greater than the specified 4 in. Not much variation in density appeared. The photographs of the cores checked the notes on inspection. Measurements showed a surprisingly close average of 50 per cent coarse aggregate in both the 1:2:4 and 1:2½:5 concrete. The absorption showed an average of about 1½ per cent. The weight per cubic foot varied from 140 to 160 lb., with some marked deviation in a few instances. After the compression test examination showed with few exceptions a sound coarse aggregate of crushed or uncrushed fragments of gravel. While the average compression test when corrected for cylinders 9 in. high by 4½ in. in diaemter averaged well above 3,000 lb. there is a slight decrease in compressive strength with the age of the concrete.

Subgrade Soils.—In connection with the field classification of pavement, and with 12 special intensive studies, classification of the underlying subsoil was made with the co-operation of experts from the Bureau of Soils and the Division of Farm Irrigation in the Bureau of Public Roads, all in the Department of Agriculture. The checked soil classification was plotted on the class-condition diagrams. The soil classification adopted was as follows:

Class 1. Clay and adobe soils (inludes clay, silty clay, clay loam and clay).

Class 2. Marsh lands (includes silt, marsh and peat lands).

Class 3. Loams (includes loam, clay-loam, silt-loam and silty-clay loam).

Class 4. Sandy loam (includes coarse sandy loam, sandy loam and fine sandy loam).

Class 5. Sand and gravel.

The classification shows that approximately 70 per cent of the concrete pavement of classes D, E and F occurs on soils of class 1.

Economic and Other Studies.—The principal economic study consisted of a state-wide traffic station for one equivalent 16-hour day at 103 stations. The blank used for counting traffic was subdivided into nine classes, as follows:

Light automobiles.
Heavy automobiles.
Busses.
Trucks less than 1-ton with pneumatic tires and less than ¾-ton with solid tires.
Trucks from 1 to 2½ tons with pneumatic tires and from ¾-ton to 1½ tons with solid tires.
Trucks from 3 to 5 tons with pneumatic tires and from 2 to 3 tons with solid tires.
Trucks, 5 tons and over, with pneumatic tires. and 3 tons and over with solid tires.
Horse-drawn vehicles.
Extra heavy vehicles.

Traffic was counted from 6 a. m. to 10 p. m., and the results are summarized in Table II. It is seen that for week days the total daily number of all vehicles averaged approximately 1,387 of which 2.7 per cent was horse-drawn traffic and 12.5 per cent truck traffic. The corresponding average Sunday traffic at 16 stations was 2,267 vehicles of which horse-drawn traffic was only nine-tenths of 1 per cent and truck traffic 4.4 per cent. (See Table III.)

TABLE II—SHOWING AVERAGE 16-HOUR WEEKDAY TRAFFIC AT 101 STATIONS.

Type.	Average vehicles per day.	Per cent of total traffic.	Per cent of total trucks.
Light automobiles	472	34.10	.....
Heavy automobiles	674	48.50	.....
Passenger busses	31	2.20	.....
Trucks, Class 1	73	5.30	42.20
Trucks, Class 2	41	3.00	23.70
Trucks, Class 3	28	2.00	16.20
Trucks, Class 4	29	2.10	16.80
Horse-drawn traffic	32	2.70	.....
Extra-heavy traffic	2	.10	1.10
Total of all vehicles	1,387	100.00	100.00
Total of trucks only	173		

Class 1—Less than 1 ton with pneumatic and less than ¾ ton with solid tires.

Class 2—One to 2½ tons with pneumatic tires and ¾ to 1½ tons with solid tires.

Class 3—Three to 5 tons with pneumatic tires and 2 to 3 tons with solid tires.

Class 4—Five-ton plus with pneumatic tires and 3 tons plus with solid tires.

TABLE III—SHOWING AVERAGE 16-HOUR SUNDAY TRAFFIC AT 16 STATIONS.

Type.	Average vehicles per Sunday.	Per cent of total traffic.	Per cent of total trucks.
Light automobiles	833	36.8	....
Heavy automobiles	1,282	56.6	....
Busses	29	1.3	....
Trucks, Class 1	62	2.7	50.5
Trucks, Class 2	18	0.8	14.6
Trucks, Class 3	10	0.4	8.1
Trucks, Class 4	12	0.5	9.7
Horse-drawn vehicles	21	0.9	17.1
Extraordinarily heavy	..	...	....
Total of all vehicles	2,267	100.0	100.0
Total of trucks only	123		

A systematic study of the motor bus traffic shows a total of 103 operating lines with an average of 610,747 passenger miles daily on the state highway system. There was also an investigation of the motor truck freight-carrying lines and a field study of the agricultural traffic. From the data developed it is estimated that a 5 ct. saving per vehicle mile on state highway pavement alone the income to the State of California during the calendar years 1919 and 1920 has been $35,000,000.

Discussion.

Standard Pavement Design.—The standard design adopted for surface was a concrete "base" of 4 in. with a ⅜-in. wearing surface of asphaltic oil and pebbles. The concrete mix was 1:2½:5 and the width was 15 ft. with 3-ft. earth shoulders.

Although the concrete surface was doubtless originally laid as a base, only approximately 43 per cent has been given the oiled surface. The average price in the earlier years for the 4-in. 1:2½:5 concrete and including grading and structures of $1.14 per square yard, was remarkably low. This price was equivalent to about $10,000 per mile of completed 15-ft. road compared very favorably with the similar price of $1.21 per square yard for oiled macadam. Neither price includes either indirect changes or overhead. The corresponding average price for the 4 in., 1:2:4 concrete laid since 1917 has been $1.84, which is also low. The concrete pavement has probably produced a smoother and more satisfactory riding surface than any of the other types incidentally laid.

This concrete pavement is the thinnest that has been extensively laid in any state and would have been rejected as too thin in any state subject to winter frosts. It is 1 ft. narrower than the minimum width of concrete roads built in most other states, and it is believed that under present conditions it is in general 3 ft. too narrow. The original mix of 1:2½:5 was leaner than that extensively used in other states, and the present mix of 1:2:4 is not as rich as usual in several states, but it is believed to be adequate for the traffic. In this connection it is to be observed that California was the pioneer state in adopting concrete as the standard pavement for the state highway system.

The ⅜-in. asphaltic oil wearing surface, or "skin top" has cost about 8 to 9 ct. per square yard and requires considerable repair and renewal and under nonabrasive rubber-tired traffic, it is not believed that it serves a purpose commensurate with its cost.

The 4-in. plain concrete of lean mix has proved in places very durable. There are 580 (distributed) miles built prior to 1917 that are of classes A and B. Under adverse conditions, particularly of soil, it is, however, evident that a pavement of such thinness has a very low safety factor and is inadequate. Its use has now been abandoned and a minimum thickness of 5 in. of reinforced concrete required. The original construction produced considerable rough surfaced concrete which as traffic developed doubtless materially increased impact. On the narrow 15-ft. pavement loads passing each other necessarily traveled close to the edge. "The crow foot" defects are doubtless due to such travel of trucks whenever the conditions were unfavorable. There is little, if any, decisive evidence that reinforcing introduced in the 4 or even in the 5-in. concrete (particularly of the triangular mesh variety) has proved effective on adverse soils or under combinations of adverse subgrade and traffic. Nor will the widening of a 4-in. pavement to 20 ft. eliminate the "crowfoot" cracks which are observed on such width concrete, even in instances on sandy soil.

The original concrete pavement design in short now has little or no factor of safety and under unfavorable conditions has not withstood the internal stresses produced by traffic flexure and variations in temperature and subsoil moisture. It is doubtful if such a safety factor can be introduced without considerably increasing the mass of concrete. It appears that under adverse soil condition there is considerable flexure with traffic.

Subgrade Soil Treatment.—Some special treatment of adverse subgrade soils, particularly of class 1, will be necessary. Capillary action and high moisture retentiveness and violent shrinkage must be met. The amount of admixture or the thickness of protective layers of non-capillary and supporting soils is not yet known. A flat subgrade might help to a slight extent to counteract such defects by eliminating some transverse tension due to normal pressure. The crown of 2¾ in. in the present 15-ft. standard design may well be reduced to 1¾ in. and with a flat subgrade and an added 1¾-in. maximum thickness there is an added factor against center longitudinal cracks.

Design of Grade, Alignment and Sections.—Many miles of the California highways lie on flat valley floors and have excellent alignment. There are scores of other miles of good location, including difficult mountain roads. It appears that the defects in grade and alignment are due largely to a too strict adherence to a standard. That standard is not invariably economical.

Other locations on hill and mountain roads evidence minimum standards that are too low for trunk lines under present traffic conditions. There are numbers of 50 and 60-ft radii curves and grades of 7 per cent that might have been eliminated or reduced at slight additional cost. In a few cases a radical change in line, though doubtless involving added right of way costs, would have been a great improvement

It appears that valuable land has often been avoided and that a location that follows closely the topography has been the rule. These elements have at intervals impaired the alignment and grade.

Specifications.—The State Highway Commission has until recently adhered to the 1912 specifications with few changes. These specifications appear to have been rigidly enforced. The grading has been neatly finished and the subgrade evidently well prepared. The original lean concrete mix of 1:2½:5 for a pavement should have been abandoned sooner and the permission of 6 per cent of the fine aggregate passing a 100-screen allows a possible excessive clay content. The requirements for coarse aggregate, with respect to size, grading, quality and cleanliness are, in the light of recent developments, somewhat inadequate. It is believed the specifications should also exclude the use of alkaline or sale water and permit larger aggregate than 2½ in. The originally required rough finish has been abandoned, but the finish now obtained can be improved. This rough finish was evidently for a pavement base, but it shows through a ⅜-in. top and, where not covered, has doubtlessly tended to increase impact. The old specifications for mixing until texture and color were uniform were evidently unsatisfactory and have been abandoned in favor of a 10-turn or 1 minute mix. The requirements for curing by ponding or wet earth cover are excellent, but some checking due either to lax enforcement of this provision for curing or to a too wet mix has occurred. The omission of transverse joints appears to have been a justifiable innovation, particularly in a frostless country, but it is believed there should be exception to this practice. The present requirement for concrete mixture of 1:2:4 if laid dry it is believed should produce a good pavement for traffic preponderately rubber tired, but it is remarked that several states use a richer mix. Reinforcement has not been required until 1920, but the present specifications for about 42 lb. of ½ and ⅜-in. steel rods in the center plane per 100 sq. ft. it is believed are excellent. The triangular mesh reinforcement used as Federal Aid Project No. 1 was a failure due possibly to improper placement.

Conclusions.

The state highway system has in general been well selected and laid out. The mileage prescribed by law has far exceeded the funds and this discrepancy distorted the policy. The mileage remaining to be built is far in excess of the combined capacity of the third bond issue and all available Federal aid.

The deferred serial type of highway bond adopted is good, but the longest terms of every issue (44-45 years) is very excessive and the long terms will require millions of needless interest. The amounts of money were sufficient to permit planning of comprehensive construction programs and economy of large operations. The legal restrictions on the bonds were seriously embarrassing. (Such restrictions were removed by the vote of Nov. 2, 1920.)

The order of selection and construction of roads from year to year has been largely controlled by necessary policy.

The policy of permitting unpaved exceptions in small incorporated towns is uneconomical and impairs the efficiency of service of the state highways.

The financial administration has been scrupulously honest and careful and the administrative and engineering costs have not been excessive, nor have final costs much exceeded the engineer's estimates.

Convict work has been successful, especially during the war, and from both aspects—the road work and reflex effect on the convict—it has been found necessary for success to largely eliminate any dual control of convicts on the job. The state prison funds clearly should bear some expense.

Motor Vehicle Traffic.—There has been a conspicuous growth of motor vehicle registration in California during the past construction period and a corresponding increase in volume and intensity of traffic. The Commission evidently did not anticipate this increase and did not provide for it in their original design, nor did they count the traffic throughout the state. A very careful traffic census at intervals should be taken.

It is not believed that modern rubber-tired traffic on a smooth concrete road is abrasive, although solid tired vehicles doubtless produce some breaking down of edges of separted cracks. There was found no definite correlation between total of vehicles and condition of the concrete pavement itself but the total traffic does largely determine the wear of shoulders and in many places indicate a too narrow width of pavement. It is believed that the impact of excessively heavily loaded trucks, particularly at high speeds, is very destructive to a thin, narrow pavement on adverse soils, but it is evident from the data that such trucks are in a small minority in California. Truck traffic is increasing and size and number of commercial passenger busses is very noticeable and there may be expected a parallel increase in the development of commercial freight motor truck traffic. Passenger busses are already operating on the 15-ft. pavement to the disadvantage of other traffic and the law allows a total width of farm load of 10 ft., which is excessive for such pavement.

State authorities cannot control the volume nor the distribution of traffic on the state highways, but complete and effecive co-operation between the State Highway Commission and the Motor Vehicle Department controlling the character of traffic is necessary. The creation of special state police exclusively to enforce the vehicle laws may be required.

There is a very large annual operating revenue to the community from the state highways. The total of this revenue has probably paid for all construction costs to date and would have been correspondingly decreased with less mileage.

A sum equal to the total net motor vehicle fees at the present average rate will probably always be required for the absolute maintenance and improvement of state highways as construction of the 5,560 miles progresses. The original theory of a license to operate a motor vehicle is obsolete in a community where 97 per cent of traffic is by motor and registration fee becomes a charge for use of the road. Systematic financing of the upkeep will ultimately adjust the average fee to the requirement of upkeep and also adjust the fee to the vehicle type to more closely indicate the wear produced. An immediate increase of the state's share of the net automobile revenue would be good economy as a large mileage of defective concrete road must be at once repaired and resurfaced.

Results of Sample Core and Soil Tests.—The tables and the diagrams of condition and the statistics of sample core and soil tests clearly indicate:

(a) A correlation between defective pavements of classes D, E. and F, and adverse soil subgrades, about 110 miles or 70 per cent of 157 miles total of these three classes occur on soils of class 1, which includes all adobe soils.

(b) That since the average corrected testing strength of concrete cores is above 3,000 lb. to the square inch concrete itself is not generally defective in strength nor does it show any wear by traffic.

(c) The average class condition of all concrete pavement indicates a slow progressive deterioration from 1912 to 1920, and that the type built tends to reach its approximate stage of classification comparatively soon and thereafter to change more slowly.

(d) The diagram showing average strength as determined by cores tested from concrete laid during the various years indicated that there may be a slow progressive deterioration of the concrete itself, or "fatigue" in a thin slab subject to excessive flexure.

(e) There is no conclusive indication so far, that the previous reinforcement in a 4-in. or 5-in. slab has produced a measurable increase in the quality or durability of the pavement.

(f) There is shown by the diagram of comparison between class condition of oil surfaced concrete and the class condition of bare concrete a slight superiority in the average condition of the pavement surfaced with the ⅜-in. oil top, but in view of obscured classification there is no demonstrated marked superiority of oil surfaced pavement.

(g) Typical longitudinal (and other) cracking found on adverse subgrade soils, and shown by many of the 7,500 photographs now on file in the Bureau of Public Roads, indicates a distortion of the subgrade due to varying moisture content and shrinkage. The diagram showing line of equal moisture content clearly indicates the influence of the concrete pavement in preventing evaporation. The high capillarity of adobe soils and the great shrinkage in the long hot summers thus produce very unfavorable conditions for a thin pavement under increasing traffic.

All pavement of Classes D to F inclusive, which totals 120 miles and much of which is on abode soils is doubtless deteriorating and demands immediate repair and supplementary construction. It is doubtful if much of the pavement of these classes, especially on adobe, will ultimately prove an adequate base for a 1½ in. Topeka top. The "second story" concrete, if extended to a total width of 20 ft. to thus include two new 30-in. concrete shoulders of full depth, is to be preferred.

Designs of Increased Strength for Future Construction.—There are sufficient typical failures to show that in the future only designs of increased strength and adapted to resist such failure should be used. There will be necessary every possible precaution to prevent failure on adverse subsoils of adobe, clay adobe, or similar soils. On such soils, in the absence of any proved successful design, short sections only of tentative design should be approved by the Secretary of Agriculture, or there should be first developed frank experimental construction to determine a workable and economical design for post road projects.

Such a design will require the reinforcement now provided by the Commission and a more massive type of concrete and not less than 6 in. in average depth and some adequate corrective treatment of subgrade and possibly a form of "mulching" of shoulders to prevent evaporation. A flat subgrade is desirable and less crown.

It is believed that on the main roads more satisfactory results will follow a considerably bolder standard of location on hill and mountain grades and that an increase in width of pavement to a minimum of 18 ft. is now desirable and with more systematic widening and super-elevation on curves.

Under modern traffic conditions there is an increasing demand for unimpaired alignment and fast travel between centers. To this end designs of highways must produce in general a road that can be traversed at a speed of thirty miles per hour throughout and without excessive operating costs due to changing speeds, etc. Therefore, first economy in grading becomes of rapidly decreasing advantage and must give way to the increased safety and comfort of travel.

There would be advantage in some exceptions to the present standard of no transverse joints. In the hot valleys considerable buckling of the 4-in. slab occurs with attendant abrasion in infrequent instances. This tendency to buckle would doubtless be reduced by a thicker slab. Experiments with transverse joints at varying intervals is desirable on adverse or adobe soils. The future pavement will require a much larger factor of safety.

There is nothing presented by the entire California study that indicates that concrete is not a successful pavement. One of the clearest results is the emphasis on the need of better subgrade protection. Highway grading is more exacting than railroad grading.

It is believed that the motor vehicle registration law should provide separate records of the numbers of (a) all commercial trucks, including rubber-tired trucks, (b) all public freight trucks of certain important classes, (c) all foreign cars, and (d) all public passenger carrying busses and should contain strict provisions regarding tire conditions on all solid tired trucks with respect to the minimum rubber cushions and flat tires, or projections, etc.

State Highway Official.—The work of the State Highway Commission and the Highway Engineer shows a continuous and intelligent devotion to public duty. Their construction operations have been widely extended under greatly varying conditions. A high degree of standardization was doubtless necessary and is evident. The failures (12.5 per cent of D, E and F pavement) are not extensive and some were inevitable on large scale work. The 4 in. 15-ft. concrete pavement was continued beyond the point of success on adverse soils and more time will be needed to develop a type of construction certain of success on such soils. The operations have produced a large mileage of very serviceable road and from an economic standpoint are conspicuously successful and of continuing benefit to the State. The operating income from the highways is now sufficiently large to insure the economic success of a considerably increased standard of construction.

New 200,000 Gal. Bituminous Material Storage Plant of Bergen County, New Jersey

Bergen County, New Jersey, has about 160 miles of roads paved with various types of bituminous construction. It also has about 67 miles of roads which are surface treated with bituminous materials, and the annual consumption of bituminous materials of all kinds of new construction and surface treatment and repairs is about 1,500,000 gal. The board of chosen freeholders and the supervisor have decided that a complete road materials storage plant, providing adequate storage facilities for bituminous materials required for road construction and for surface-treating, is in accord with good business policy and will prevent delays incident to the difficulty of obtaining prompt shipments during the busy season. If at any time the supply on hand is in excess of the county's requirements, the authorities contemplate furnishing material to municipalities or contractors working upon their roads. The plant is to be located in county yard No. 2 at Hackensack, N. J. This yard is situated on the Erie railroad and the county authorities have constructed a railroad siding on the property.

Plans and specifications for the plant, which is to be a model of its kind, have been drawn by Dow & Smith, consulting engineers, New York City. Bids for its construction will be opened May 9 by J. E. Thier, county supervisor of roads, Hackensack, N. J. The plans call for four 50,000 gal. storage tanks and two 4,000 gal. heating tanks. The storage tanks are insulated by means of 6 in. hollow tile walls built up around them and are provided with sufficient steam coils to keep the material in a fluid condition. The heating tanks are insulated with magnesia blocks and are provided with a relatively larger steam coil installation, which will heat the materials to the temperature required for application on the road. These tanks will be filled by gravity from the storage tanks except when the material in the latter is at a very low level. All of the bituminous material storage tanks are surrounded by dam walls 2 ft. in height to take care of any overflow or boiling over of the material contained in them. The bituminous material and fuel oil will be received in tank cars on the railroad siding which runs along the easterly side of the plant. For handling the bituminous material two rotating plunger pumps are provided, each one of which is normally designed to take care of unloading tank cars and pumping their contents into two of the main storage tanks and one of the heating tanks. The pumping is so designed that in case of a breakdown, any one pump can be connected up so as to take care of all four storage tanks and both heating tanks. The steam for the plant is generated in a boiler house of appropriate design and constructed of reinforced concrete and hollow tile, and fuel oil is to be used under the boilers. Two 10,000 gal. tanks, buried underground, supply the necessary fuel oil storage and are filled from the siding by means of a duplex piston pump, and are connected up with the necessary burner pumps and steam connections.

All the pipes for carrying bituminous material are steam jacketted and provided with the necessary air connections so that they can be blown out after use. The pipes are carried 2 ft. above the ground level and rest on top of the dam walls, thus rendering them easy of access when repairs are necessary.

On the westerly side of the plant, a road has been constructed 6 ft. below the level of the railroad siding. The necessary swing pipes have been provided for the discharge of the heated bituminous material by gravity into tank wagons on this roadway, thus minimizing the amount of pumping required. All tank foundations and retaining walls are to be made of reinforced concrete.

Mechanical Handling of Gravel in Pits

Brant County, Ontario, makes exte[illegible] [illegible] of mechanical plant for handling and transporting road building materials. In a paper presented at the conference last month of the County Road Superintendents and Engineers of Ontario, Canada, Mr. A. M. Jackson, Engineer of the county, gave some interesting information on the methods employed in his county.

He gives the following figures on the mechanical handling of gravel in pits when a crusher is used, based on an output of 100 tons per day.

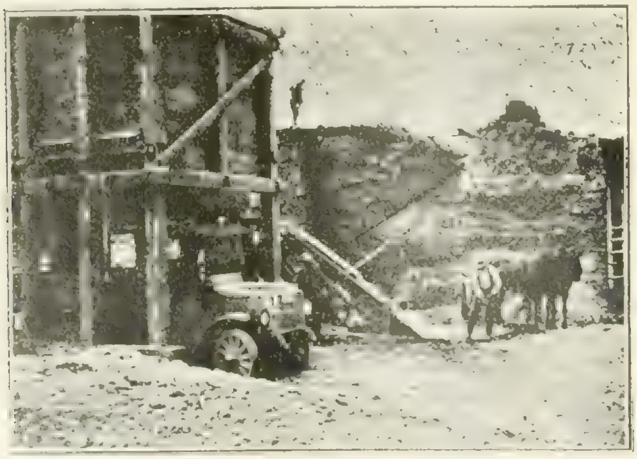
One acre of gravel with a 10-ft. face would produce approximately 20,000 tons. If such an acre is taken as costing $500, this would represent a unit cost of 2½ ct. per ton of gravel. The daily cost of operation would be:

	Per day.
[illegible] tractor and operator	$11.00
Two teams with slip scrapers	16.00
Two men feeding and dumping	8.00
Fu[illegible]	3.80
Oil and grease	1.20
Total	$40.00

On a basis of 100 tons output per day the cost would be 40 ct. per ton plus 2½ ct., making the total cost 42½ ct. per ton.

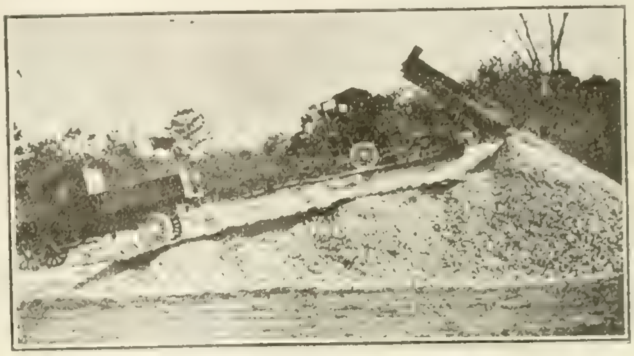
Mr. Jackson states that in one pit where a bonus of 40 ct. per ton was paid on all over 100 tons produced per day, some two weekly periods averaged as high as 120 tons per day. Mr. Jackson has found that the above was the limit of the 9-in. x 16-in. jaw crusher used with the 1¼-in. jaw opening and that when the material was sticky after rain, production dropped as much as 50 per cent. Generally speaking, two methods of getting the gravel from the face into the crusher were used. In the larger pit with a face of 28 ft., running probably 30 per cent stone that would be broken by a 1¼-in. jaw opening, a standard 18-ft. conveyor to the crusher was used. The conveyor discharged on a plate with 1½-in. holes in it, set at about 30 per cent slope. In dry weather, good separation was obtained here as the material passed over the plate, large sizes to the crusher, fines to the elevator. A grizzly set almost level and jigged by a cam motion would give much better results, however, in all weathers.

The elevator used was 30 ft., filling into a 50-ton bin with center discharge through four 12-in. x 12-in. openings in the bottom. The bottom discharge gives, Mr. Jackson considers, better results than the side discharge as the load is deposited in the center of the truck and needs no spreading, although the bin must be of sufficient height to allow trucks to pass clear underneath, necessitating a longer elevator. When an elevator is used for depositing crusher run gravel in a bin, the material forms itself into a cone and the coarser particles roll down to the bottom leaving a central cone of fines. In drawing from the bin, whether of the bottom or side discharge type, the loads vary somewhat, some being composed largely of fines, some largely of coarser materials. Mr. Jackson found that the use of a grader to spread the crushed product on the road partially overcame this defect, but he feels that an entirely satisfactory solution of the problem is yet to be found. These conditions apply only in the case of crusher run gravel.



[illegible]ding Truck, 5 Tons in ½ Minute. The Operator Is Shown Feeding Gravel, Dumped by Scraper, From Pocket Onto Conveyor Leading to Crusher.

The other method used in getting gravel to the plant was to sink the crusher and build a platform over it, with a pocket about 2 ft. square above the jaws. With this method, all material, fine as well as coarse, will pass through the crusher—a distinct disadvantage. Mr. Jackson found, however, that 2 teams could with scrapers keep a pile 3 ft. high above the crusher jaws and that a 9-in. x 16-in. crusher 1¼-in. jaw opening would produce about 80 tons per day of 10 hours.



Making Stock Pile of Crushed Stone.

Reinforced Concrete Guide Posts of Wayne County Highway System

An ornamental reinforced concrete guide post, 10 ft. high, set in a concrete foundation, has been adopted for the roads unden the jurisdiction of the Road Commissioner of Wayne County, Michigan, according to a paper presented at the recent convention of the American Road Builders' Association by Edward N. Hines, chairman of the commission.

The road signs are securely fastened to these concrete posts with metal brackets. The basis of distance is taken from the campus in the city of Detroit. One wing of the sign gives the distance to the next town, the distance back to the heart of Detroit, and the distance to the termination of the route; for instance, on Michigan Ave. road to Chicago. The name of the road is also given. The side or cross-road wing of the sign gives the name of the towns or the route which is available to traffic to turn off from the main artery of travel. Where there is no important center to which the road leads, the name of the road alone is shown on the signboard. No arvertising signs nor boards tacked on telephone posts or otherwise which are in the right of way of the road are allowed. Provision is also made to place electric lights on each post as soon as funds may be available, so that the traveling public may read the signs at night, as well as in the day time.

Road Building in Quebec in 1920.—During 1920 the Province of Quebec, Canada, completed 452 miles of improved roads, according to the report of the Quebec Roads Department. In addition 179 miles were under construction at the end of the season. The mileage of the different classes of highway built in 1920 and 1919 was as follows:

	1920. Miles.	1919. Miles.
Waterbound macadam	80.60	93.94
Gravel	350.81	341.77
Bituminous macadam	13.24	5.87
Concrete	7.57	6.75
Asphaltic concrete	None	3.07
	452.22	451.40

Betterment of Old Roads in California.—The California Highway Commission, in widening and thickening the old pavement to care for increased traffic, has in some locations placed a second concrete slab over the old slab. In other places concrete shoulders have been built 1½ in. higher than the original slab and the trough thus made filled with asphaltic surfacing. At the present time the commission is building a 5-in. oiled macadam road using the original concrete slab as a foundation on certain sections in the rice growing district, where, owing to inundation of the roadbed from adjacent rice fields, disintegration occasioned by alkali salts carried in solution in this water and the excessive loads hauled on the roads, the concrete slab has been broken into fragments.

Motor Vehicle Registrations, Licenses, and Revenues in the United States During the Calendar Year 1920

By ANDREW P. ANDERSON,
Highway Engineer, U. S. Bureau of Public Roads.

A total of 9,211,295 motor cars, including commercial vehicles, was registered in 1920 in the 48 states and the District of Columbia. There were also registered a total of 238,146 motorcycles. The registration and license fees including those for chauffeurs, operators and dealers, amounted to a total of $102,034,106.26.

As compared with 1919, the data for 1920 represent an increase of 22 per cent, or 1,645,849 motor cars. This increase alone lacks only about 4 per cent of being equal to the total registrations of the United States for the calendar year 1914. In this connection it is interesting to note that the number of motor cars registered in 1920 in the state of New York exceeded the total cars registered in the United States in 1910. Furthermore, the revenues derived from the registrations in the state of New York in 1920 were about equal to the entire registration revenues of the United States for the year 1913. The revenues derived from all registrations and licenses during the year 1920 exceed those of 1919 by 58 per cent or a total of $37,336,850.68, which increase is practically equal to the total registration revenues of the United States for the calendar year 1917.

The increase in the motor car registrations and revenues in the United States during the past 14 years presents many interesting comparisons. This is especially true in respect to the use made of the revenues. In 1906 the total registrations were approximately 48,000 cars, paying a gross revenue of about $193,000, or about the same as that collected by the state of Arizona during the year 1920. In 1906 the gross registration revenues were equivalent to less than three-tenths of 1 per cent of the total rural road and bridge expenditures for that year, while the registration revenues for 1920 are equal to about one-fourth of the total rural road and bridge expenditures for the calendar year 1919. Furthermore, while in 1906 practically none of the motor vehicle revenues was applied to road maintenance or construction, in 1920, 96 per cent, or a total of $97,997,160.60, was used for this purpose, and of the total amount applied to road work, 79 per cent or $77,531,582.57 was expended under the control or supervision of the several state highway departments. The remaining 4 per cent not applied to road work was expended very largely for number plates and in the carrying out of the provisions of the motor-vehicle registration laws in the several states.

On January 1, 1921, every state but Minnesota had made provision for some definite form of annual state registration. In Minnesota a 3-year registration period ended on Dec. 31, 1920. The registration figures for Minnesota, therefore, are the total number of cars registered during the period of three years. How many of these cars have been removed from the state or have been scrapped there is no way of determining. A few states make as yet no distinction between original registrations and re-registrations or transfers. Consequently in these states the number of registrations is in excess of the actual number of cars. In most states, however, the registration figures represent fairly accurately the actual number of cars in the state during the year.

For a number of years the general tendency toward devoting an ever-increasing portion of the net motor vehicle revenues to road work under the control and direct supervision of the state highway departments has been very noticeable. Prior to 1912 only a very small portion of the motor vehicle registrations was devoted to road work under the state highway departments In 1920, however, 76 per cent of the total motor vehicle revenues, or $77,531,582.57, was applied to road work under the direct supervision of

TABLE I—MOTOR VEHICLE REGISTRATIONS AND REVENUES, 1920.

State.	Automobiles.	Motor trucks and commercial vehicles.	Motorcycles.	Re-registrations or transfers.	Owners' and chauffeurs' licenses.	Manufacturers' and dealers' licenses.	Total gross motor-vehicle registration and license revenues.	Motor vehicles revenues available for road work.		Av. gross revenue return per motor car registration.	Population per motor car.	Motor cars per mile of public rural road.
								By or under State Highway Department.	Under direction of local authorities.			
Alabama	61,941	12,696	1,035	1,200	3,413	1,411	$ 835,178	$ 668,142	$	$11.23	31	1.3
Arizona	29,868	4,733	542	1,816	417	251	192,368	189,868	....	5.55	10	2.9
Arkansas	59,082	...[1]	.....[2]	333	478	548	591,464	550,000	....	10.01	30	1.2
California	534,814	34,078	20,047	126,827	865,699		5,554,265	2,777,132	2,777,132	9.76	6	9.3
Colorado	121,506	7,749	3,420	11,509	131,449	2,822	819,872	375,699	375,699	6.34	7	3.2
Connecticut	95,123	24,011	6,543[3]	20,156	139,843	814	1,852,591	1,852,591	...	15.55	12	8.5
Delaware	18,300	.....[1]	674	(1)	22,023	606	329,980	329,980	...	18.03	12	5.0
D. of Columbia	29,131[14]	5,030[15]	2,648	1,189	17,767	927	266,285	....	.	7.78	13	...
Florida	63,466	10,448	1,275	1,544	2,190	719	554,695	554,695	......	7.63	13	4.1
Georgia	134,000	12,000	1,382	2,894	5,055	976	1,919,338	1,851,540	.....	13.14	20	1.8
Idaho	50,861	.....[1]	764	851	802	581	882,034	220,508	661,525	17.34	8	2.0
Illinois	504,250	64,674	10,569	(1)	566,701	6,239	5,915,700	5,915,700[5]	....	10.40	11	5.9
Indiana	300,226	32,841	8,823	(1)	9,758	1,500	2,029,694	1,902,363	....	6.09	9	4.5
Iowa	407,578	29,800	4,000	90,000	3,870	2,575	7,507,202	7,244,450[6]	...	17.16	5	4.2
Kansas	294,159	....[1]	3,605	12,598		2,411	1,419,345	....	1,327,308	4.83	6	2.6
Kentucky	99,437	13,246	1,543	(1)	5,000	1,016	815,549	815,549	....	7.24	21	1.9
Louisiana	66,000	7,000	512	602		515	390,000	....	350,000	5.34	25	3.0
Maine	55,395	7,512	1,566	(1)	78,539	637	818,755	818,755[5]	....	13.02	12	2.7
Maryland	87,625[7]	15,216[8]	5,222	9,960	54,269	4,368	2,124,924	1,537,540	384,385	20.53	14	6.2
Massachusetts	223,112	51,386	15,143	30,000	361,546	2,011	3,860,231	3,506,000	....	14.07	14	14.7
Michigan	366,946	45,771	8,011	35,640	195,477	1,638	5,754,900	2,745,715	2,737,138	13.94	9	5.6
Minnesota	324,166[9]	....[1]	7,546	5,716	8,920	641	143,794	143,794	.....	.44	7	3.5
Mississippi	63,721	4,765	194	834	63,267	260	800,000[10]	750,000[10]	...	11.68	26	1.5
Missouri	297,008	...[1]	3,954	16,400	323,799	2,520	2,111,696	2,111,696	...	7.11	11	3.1
Montana	59,450	1,200	675	862	1,490	429	416,245	280,557	93,519	6.86	9	1.5
Nebraska	200,000	19,000	2,100	(1)		3,000	2,800,000[10]	2,100,000[10]	700,000[10]	12.78	6	2.7
Nevada	10,464	....[1]	125	(1)	....	75	103,318	103,318[5]	......	9.87	7	.9
New Hampshire	30,240[11]	4,440	2,542	4,475	[illegible]	252	654,702	580,342		18.69	13	2.5
New Jersey	204,125	23,612	11,041	41,351	294,438	2,671	3,503,936	3,441,770	....	15.39	14	15.3
New Mexico	22,100	..[1]	219	(1)	.	175	200,000	180,000	.....	9.05	16	.6
New York	521,417	148,873	29,453	..	358,022	....	8,511,597	6,383,697	2,127,899	10.16	15	8.3
North Carolina	127,405	13,455	1,418	.		....	1,785,000	1,785,000	.	10.26	18	2.7
North Dakota	90,840	.....[1]	898	10,150	.	....	691,500	274,257	274,257	7.61	7	1.3
Ohio	538,090[12]	83,200	23,300	(1)		24,244	6,400,000[10]	3,100,000[10]	3,100,000[10]	10.30	9	7.2
Oklahoma	204,300	8,580	1,360	(1)		1,202	2,500,000[10]	2,294,404[5]	....	11.74	10	2.0
Oregon	103,790	....[1]	3,434	16,568	142,962	751	2,085,168	1,469,145	489,715	20.09	7	2.9
Pennsylvania	521,835	18,329	23,981	57,712	261,183	13,154	8,090,873	8,090,873	..	14.01	15	6.2
Rhode Island	40,914	9,563	2,260	5,790	58,710	231	531,462	468,162	.	10.51	12	23.3
South Carolina	93,843	...[1]	908	1,933		1,541	527,868	92,529	329,765	5.63	18	2.2
South Dakota	112,589	7,806	777	2,545	...	1,071	784,000[10]	....	700,000[10]	6.51	5	1.2
Tennessee	90,214	11,638	1,151	5,754		564	1,215,776	571,816	571,816	11.94	23	2.2
Texas	427,693	...[1]	4,290	121,280	23,385	3,624	3,510,355	1,468,474	1,715,416	8.21	11	3.3
Utah	37,060	5,556	1,114	(1)	1,120	235	350,933	325,000[5]	..	8.23	11	4.8
Vermont	28,709	2,916	946	3,290	39,201	192	555,422	515,736	.	14.10	11	2.2
Virginia	101,800	13,670	2,233	(1)	5,514	2,972	1,822,736	1,730,931	.....	15.70	20	2.1
Washington	111,131[13]	29,789	4,915	13,337		3,977	2,828,896	1,800,000[10]	1,000,000[10]	16.15	8	4.1
West Virginia	69,862	10,802	1,659	(1)	10,552	886	1,280,193	1,096,662	.....	15.87	18	2.5
Wisconsin	277,093	16,205	8,002	(1)	.....	1,946	3,127,073	2,250,000	750,000	10.67	9	3.8
Wyoming	23,926	.....[1]	327	(1)	....	201	267,179	267,179[5]	......	11.16	8	1.6
Total and Av.	8,369,605	841,690	238,146	655,116	4,100,852	99,379	$102,034,106	$77,531,582	$20,465,578	$11.08	11	3.8

[1] Included under automobiles. [2] Registration not required. [3] Includes 2,178 side cars. [5] To pay interest and provide sinking fund for state highway bond issue; remainder for state highway work. [6] Distributed to counties but expended under supervision of state highway department; 2½ per cent of grand total, to state highway department for expenses. [7] Does not include 13,500 non-resident registrations. [8] Includes 4,022 buses and vehicles used for hire. [9] Registrations cover a period of three years ending December 31, 1920. Number of cars given are for total period; revenues are for calendar year only. [10] Approximate. [11] Does not include 2,359 non-resident and neutral zone cars. [12] Does not include 2,683 state, county and city cars. [13] Does not include 1,287 exempt cars. [14] Does not include 14,797 non-resident cars. [15] Does not include 1,790 non-resident trucks. [16] Data cover period of 18 months, ending December 31, 1920.

the state highway departments, and $20,465,578.04 additional was applied to road work by counties or other local supervision, but with little or no direct supervision from the state highway departments.

In most states the motor vehicle revenues are devoted to maintenance and repair of the state roads or other improved highways. These states thus seem to have solved fairly well the difficult problem of securing funds for the maintenance of the more important roads under the ever-increasing traffic requirements. As both the traffic and the revenues increase with the number of cars there seems to exist a possibility of so adjusting the registration rates as to keep pace with the ever-growing maintenance changes.

A number of states having in general but a small mileage of improved roads have recently adopted the plan of capitalizing the motor-vehicle revenues and devoting these funds to road construction. These states are: Illinois, Maine, Minnesota, Missouri, Nevada, Utah and Wyoming. In these states bonds have been voted or issued for road construction, and the principal and in some cases also the interest is to be paid entirely from the motor-vehicle revenues. There seems to be no doubt that these revenues may be made sufficient for this purpose. The question as yet to be solved by these states is, from what other source can sufficient maintenance revenues be secured so as to prevent the deterioration of the roads constructed from the bond issues.

At the beginning of 1921, there were still 7 states in which motor trucks were registered at the same rate as passenger cars. The past five or six years, however, have shown a very decided tendency toward increasing the fees required for heavy motor trucks over and above those required for passenger cars. This increase is usually based on the weight of the truck, its carrying capacity, its horsepower, or a combination of these factors. The most general practice seems to be toward definitely limiting the maximum total loaded weight of the vehicle and basing the registration fee on the carrying capacity of the truck. Some few states have adopted a scale of fees which in actual practice serves to make the operation of very heavy trucks unprofitable. A number of states have also provided legislation to limit the maximum wheel load per inch of tire.

It is unfortunate that the term motor truck and commercial vehicle is as yet rather indefinitely defined in the laws of a number of the states. In a few states no distinction is made between passenger cars and freight carrying vehicles, while in one state only trucks used for hire are classed as commercial vehicles.

The states of Colorado, New Mexico, and Oregon, in addition to the registration fees, also levy a state tax on gasoline or other products used for the propulsion of motor vehicles. In Alabama, Delaware, Idaho, Iowa, Michigan, New Hampshire, New York, North Dakota, Oklahoma, Oregon. South Carolina, Pennsylvania, Tennessee, and Vermont, the registration fees are in lieu of all personal property taxes. In other states, however, motor cars ars taxed as personal property in addition to the required registration fees. In comparing the registration rates in the several states this fact should be borne in mind.

The registration of automobiles, motor trucks, commercial vehicles, chauffeurs, and operators, dealers, and manufacturers, as well as the total gross revenues and the amount available for state road work, either by the state highway departments or under their supervision and that available for local road work for the year 1920 are given in Table I. The number of registrations in this table does not necessarily indicate the exact number of motor vehicles in use or existence in the several states except in so far as the laws of the several states require and enforce an annual registration under these classifications. All of the states with the exception of Minnesota now require an annual registration. Some states, however, do not segregate registrations from re-registration, consequently the registration figures in these states exceed the actual number of cars by the number of transfers which have been made during the year. It is unfortunate that, during 1920, only 36 states required motor trucks and commercial vehicles to be registered in separate classes. Consequently the data in column 3 in Table I do not give a very definite index as to the total number of trucks in existence except in these states requiring separate registration. Even where separate registration is required the classification as to what constitutes a motor truck is far from uniform.

Justifiable First Cost of Highways

By J. E. PENNYBACKER,

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Determination of justifiable outlay for a proposed highway improvement from anticipated service should call for at least as careful survey and estimate as the engineer now provides for the engineering features preliminary to the construction of the highway. Millions of miles of earth roads and thousands of miles of lightly surfaced and poorly designed gravel and macadam roads impose upon the highway engineers of the nation the task of so parceling out insufficient highway revenue that it will be applied to the highways in proportion as they show traffic justification for improvement.

To incorporate this requirement into highway engineering practice is to make the traffic unit as widely used as the customary units of physical measurement. This measurement of justifiable outlay by the yardstick of traffic does not disregard the profound beneficial influence of the highway upon social life and educational development in rural districts, but inasmuch as they go hand in hand with traffic development the latter may in general be regarded as an index of both the direct and indirect value of the improvement.

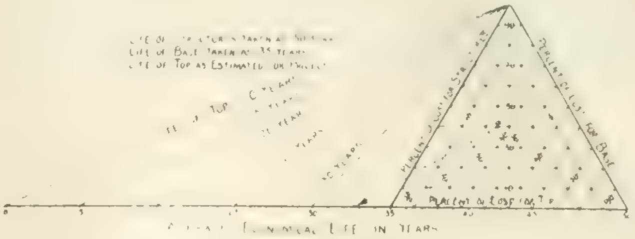


Fig. 1—Average Economical Life of Highway Governing Term of Bond Issue or Investment.

Motor vehicle traffic predominates to such an extent as to make logical the adoption of a system of measuring costs and justifiable outlay primarily in units derived from this class of traffic. Thus while the unit commonly used for horse-drawn traffic is the ton-mile and applies to loads rather than to vehicles, it is necessary to adopt a unit which will take into account the 8,250,000 passenger automobiles now registered and the millions to come and which will allow credit to the highway for the saving in their operating costs. To substitute "vehicle mile" would not fully meet this need as the million trucks in use and those yet to come must be rated as deriving greater benefit individually than the passenger car. A simple plan sufficiently comprehensive to meet most needs is to retain the "ton mile" as the unit of measurement but to regard each passenger car and each one and two-horse vehicle as the equivalent of one ton while the motor truck and the heavy team outfits would be regarded as the equivalent of the vehicle weight plus the load in tons. This plan would permit of a rapid traffic enumeration without complexity. Subdivision of the investigation to determine whether the route is to be for "heavy truck traffic," or for "light traffic" would require segregation of the heavy and light truck records respectively, but this would not affect the main purpose of the investigation, namely, to ascertain justifiable outlay.

Counting the traffic on the old road is manifestly an inadequate method of ascertaining total ton miles. After the highway is improved it will divert traffic from other highways, will stimulate local traffic so that more miles will be traveled in a given period, increase deliveries from and to market points; develop resources and finally, if it is on a truck line or a route to scenic and recreational regions, it will draw increased tourist travel. These various classes of anticipated travel may be termed "potential" and however difficult of exact estimate the investigator should give weight to them in his recommendation as to justifiable outlay. It is suggested that for the potential local traffic a zone be plotted to include the territory which might logically be served by the highway after improvement. Within this zone the investigator could make an approximate automobile census and so acquaint himself with the business, industrial and social factors and possibilities of the zone as to establish a basis for estimating both the saturation point in motor vehicle ownership and the average mileage per car. In short, without attempting to present here the exact detail of a traffic survey, I do mean to urge the necessity and practicability of a traffic census which covers both existing and potential traffic.

Operating costs of motor vehicles are ascertainable and may be expressed in ton mile units. Costs of gasoline, oil, tires, repairs and depreciation, garage, chauffeur, taxes, etc., make a substantial total. How the figures look from a national standpoint may be gleaned from statistics. Thus, in 1920 the gasoline consumed by motor cars amounted to 3,200,000,000 gal. worth nearly a billion dollars at prices paid by car owners. Tires are estimated by M. O. Eldridge, Director of Roads of the American Automobile Association, at one billion dollars a year. Mr. Eldridge says: "Compare the smooth resilience of Fifth Ave., New York, with the rough, gritty and flinty surfaces so often encountered on country roads and try to imagine what a tidy sum in tire bills would be saved if we could all travel on 'avenue' surfaces." Lubricating oils to the extent of about 175,000,000 gal. worth as many dollars, were required. Repairs and depreciation on 9,250,000 cars, if averaged at only $250 per annum, would yield a total of more than two billion dollars. License fees alone in 1920 aggregated about one hundred million dollars and this, together with costs for garage, chauffeur, insurance and miscellaneous items, make it evident that on a conservative basis of estimating we can place the annual motor traffic cost at near five billion dollars, or the equivalent of ten times the entire highway expenditures outside of cities. The average per car, if we use 9,250,000 as the number of cars and $5,000,000,000 as the annual cost, would be $540. If the average mileage is 5,000 the cost per car mile is 10.8 ct. Applied to ton miles the average would be somewhat lower as the trucks loaded would average 3 tons, thus making it probably 8.9 ct. As to whether such a rate per mile is too high or too low on a given highway should be ascertained by the investigator. When he has determined upon the rate, however, and applied it to the potential ton miles, he has established the gross traffic cost on the highway for potential traffic if no saving were effected.

The cost of operation per ton mile on the old road should be ascertained and from this should be subtracted the estimated cost of operation per ton mile on the improved highway established by comparative data of operating costs on highways similar to the type or types under consideration for the improvement. As the traffic cost per ton mile would be affected by the character of the highway improvement to be adopted it is assumed that the engineer will base his comparison upon a type or types of improvement which appear to him practicable if they can be financed out of the traffic saving. In other words, this method leaves to the engineer the same discretion as he now customarily exercises in selection of design but subjects it to the test of financial justification. This saving in cost of traffic operation per ton mile when applied to the total existing and potential increase in ton miles gives the gross annual saving in traffic operation attributable to the improvement.

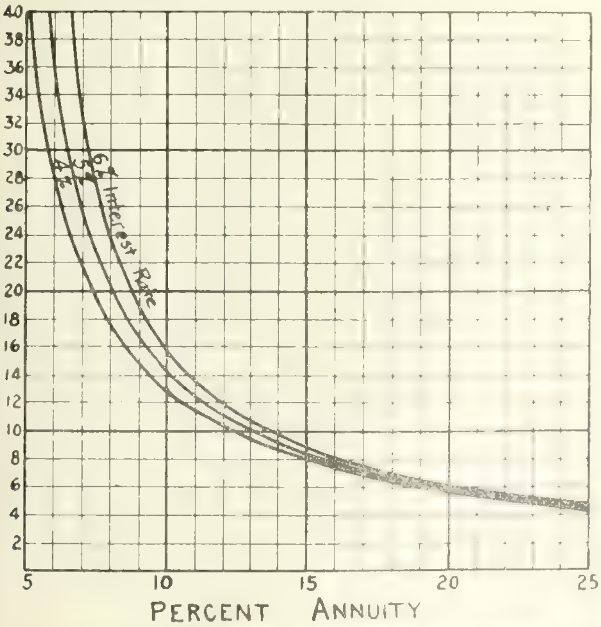


Fig. 2—Per Cent Annuity Required to Retire An Investment With Interest at Various Rates.

The net annual saving in traffic operating costs is arrived at by deducting from the gross annual saving the increase in the annual highway budget for interest, maintenance and depreciation of the improvement. In order to obtain the annual cost chargeable to interest and depreciation it is necessary to estimate the economical life of the improvement contemplated and take that amount which at the end of the period will have discharged all interest and retired the principal.

Considerations which determine the economical life of the improvement, or the period beyond which it may no longer be maintained as such without prohibitive cost, involve not only a study of the durability of pavements of the various types, but also the durability of the foundation and of such improvements as acquirement of right of way, reduction of grades, elimination of curves and grade crossings and installation of permanent structures, etc. If these latter features form a considerable portion of the first cost the term in which traffic saving is expected to pay for the project should be correspondingly lengthened. If, moreover, a pavement such as sheet asphalt or asphaltic concrete is used it may be renewed at the end of its economical life without as a rule incurring any additional expense for foundation. To compare one type of pavement with another as to their durability the important point must not be overlooked that renewal may be extensive or merely the renewal of the surface. The most rational plan is to estimate first the durability and cost of structure, etc., as Class I, foundation as Class II, and surface or wearing course as Class III, and obtain a weighted average of durability for the entire project in which the factors would consist of the life and the per cent of cost of each class of improvement. Figure 1 may be used in determining the economical life of the improvement.

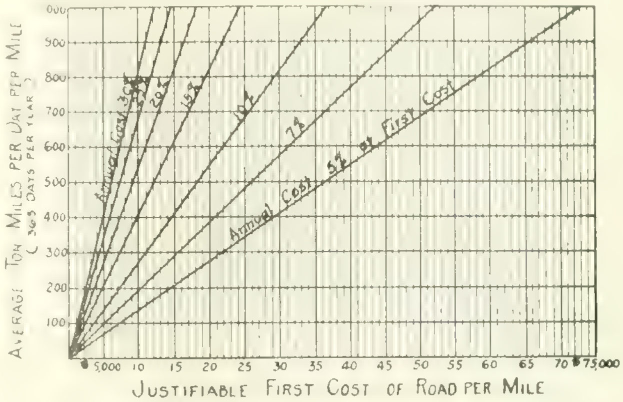


Fig. 3—Justifiable First Cost of Road Per Mile With Savings of 1 Ct. Per Ton Mile.

In this chart a life of 50 years is assumed for Class I, 35 years for Class II and from 10 to 30 years for Class III improvements. From the point at which the per cent of total cost lines for surface, base, and structures intersect for a given project an imaginary line is projected paralleling the 10-year line if the surface is estimated at 10 years; the 20-year line if 20 years, or the 30-year line if 30 years. Intermediate ages can be plotted between these limits. The intersection of the projected line with the base gives the average economical life of the road or investment.

As an example it is ascertained that Class I improvements represent 25 per cent, Class II 35 per cent and Class III 40 per cent of the total cost of improvement. This point is located on the triaxial diagram at (a). If the estimated life of the wearing course is 20 years a line a-b should be drawn parallel with the 20-year line intersecting the base line at (b) which shows an average economical life of 32½ years for the road and also of the period in which the investment should be paid off.

As the cost of the improvement is logically expressed in the form of annual outlay for interest, depreciation and maintenance, Fig. 2 may conveniently be used to ascertain the annual per cent of first cost required for interest and depreciation over the period covering the economical life of the improvement. The curves are plotted to show interest rates of 4, 5 and 6 per cent; ordinates show terms of years and the abscisses show per cents of total cost for combined annual interest and depreciation.

Maintenance costs may increase or decrease by reason of the improvement. Wherever the difference between the old and the new costs may be, it should be taken into account by adding to or subtracting from the annuity determined by use of Fig. 2 as illustrated in the example which is given later.

The chart in Fig. 3 shows the justifiable first cost at a saving of 1 ct. per ton mile for any number of ton miles per day up to 1,000 for improvements estimated to require for interest, depreciation and maintenance 5 per cent, 7 per cent, 10 per cent, 15 per cent, 20 per cent and 25 per cent, respectively, of first cost.

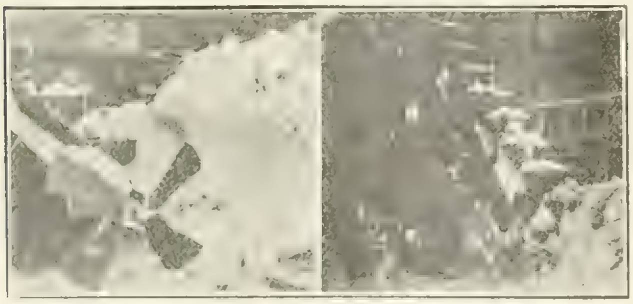
To apply the chart assume as an example an 800 average daily ton mile traffic with a prospective saving of 1 ct. per ton mile and that the engineer desires that the project be completely paid for in 32½ years. Reference to Fig. 2 shows that with interest at 5 per cent the annual cost is 6.2 per cent of the first cost for interest and retirement. The point in Fig. 3 for this latter per cent with a daily traffic of 800 ton miles would give $47,000 as justifiable first cost. An adjustment may then be made for maintenance by turning to cost records of the old highway and ascertaining if the annual cost of maintenance is greater or less than that indicated by the estimated annual cost of maintenance for the improved highway. If, for example, the annual cost of maintaining the existing road is $800 per mile and the estimated cost for the new road $300 per mile, an annual saving of $500 per mile is indicated. Next should be ascertained what investment is justifiable on account of this saving for the same period and rate of interest previously decided upon. In other words $500 is equal to 6.2 per cent of what sum? This is found to be about $8,000, which added to the $47,000 previously derived, gives a total of $55,000 as justifiable first cost.

It may not be amiss to emphasize here the far reaching importance of saving in maintenance cost as justification for improvement in the highway. It is too generally the practice to charge to the improvement the full maintenance cost as well as the full interest on initial cost throughout the entire period.

The practice of proportioning outlay to traffic value of the project will become systematized in time. Preparation and design and selection of type in the light of obtainable traffic data can be made more definite and practical without curtailing the exercise of engineering construction judgment. Rather it will broaden the scope of the engineer.

Mechanical Loading of Snow

Experiments conducted in New York City following the heavy snowfall of last February demonstrated that mechanical loading of snow was both possible and practical. One of the mechanical loaders used on this work is illustrated below. The machine shown is a Haiss path digging wagon loader, equipped with the Haiss patented revolving self-feeding propellers. The snow is fed from both ends of the propellor feeding shaft into the buckets. It is self-propelling in both directions, and has a slow crowding effect, which keeps the blades pressed steadily in the snow bank. The machine demonstrated was from stock. Next winter, however, a machine will have been built specially for the quick loading of snow. It is planned to design this new machine so that it will cut a clean path 8 ft. wide in one operation. The loading speeds also will be increased 100 to 200 per cent over those necessary for loading sand, etc. This snow loader of the path digging type will have the patented self-feeding propeller equipment.

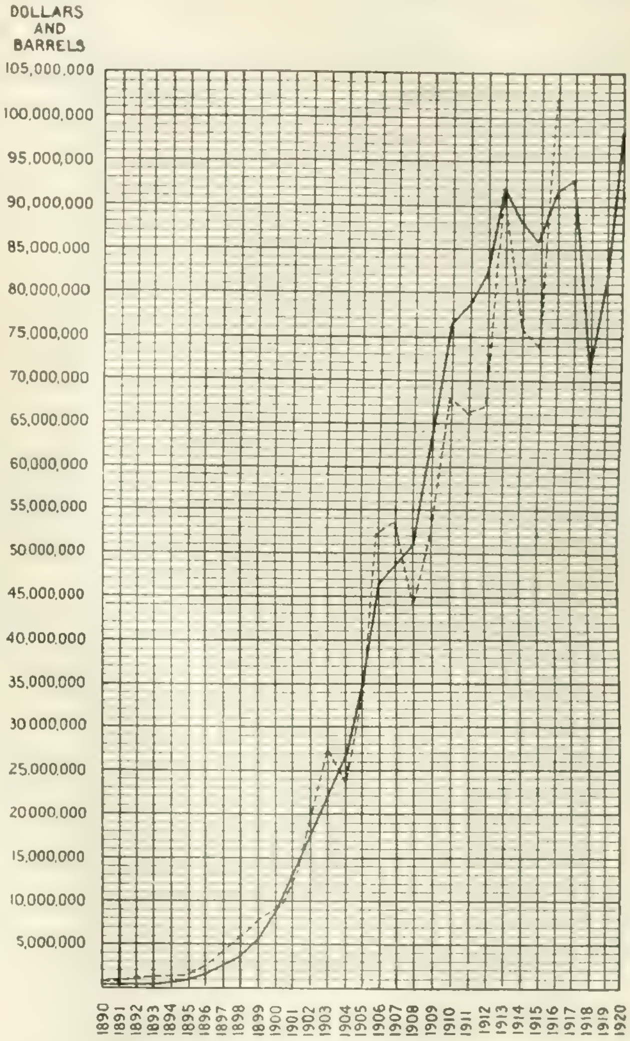


Propellor Feeding Snow Into Buckets of Wagon Loader.

Actual Costs of Cement Manufacture and Estimated Costs for a State Owned Plant

The following very pertinent data on the cement business are taken from an article by Mr. H. E. Hilts in the January number of "Public Roads"—the official paper of the Bureau of Public Roads of the U. S. Department of Agriculture.

These data are presented as parts of a discussion of the requirements of, and conditions to be met by, prospective state-owned plants for cement manufacture. The tabular matter is here quoted in nearly complete form, but only brief abstracts are made from the accompanying text.



PRODUCTION OF PORTLAND CEMENT 1890-1920

PORTLAND CEMENT PRODUCTION ————

PORTLAND CEMENT VALUE - - - - - - - -

Fig. 1—Production of Portland Cement.

Mr. Hilts finds that only under extraordinary conditions can a state owned and operated cement plant be expected to prove economic. The most important of the considerations leading to this conclusion are as follows:

(1) The highly seasonal character of the requirement for cement road construction in most states.

(2) The fact that where only one public plant is installed in a large state there will be freight costs of from 25 to 50 ct. per barrel for shipment to distant points. (In Pennsylvania, for instance, this differential for a plant centrally located might amount to 30 ct. per barrel at Eastern and Western points.) But at that, central plant production will usually be cheaper than production at scattered plants like those of the private operators, the volume of whose business may make such plants economic.

(3) The admittedly greater cost of any kind of work when done publicly than when conducted as a private enterprise.

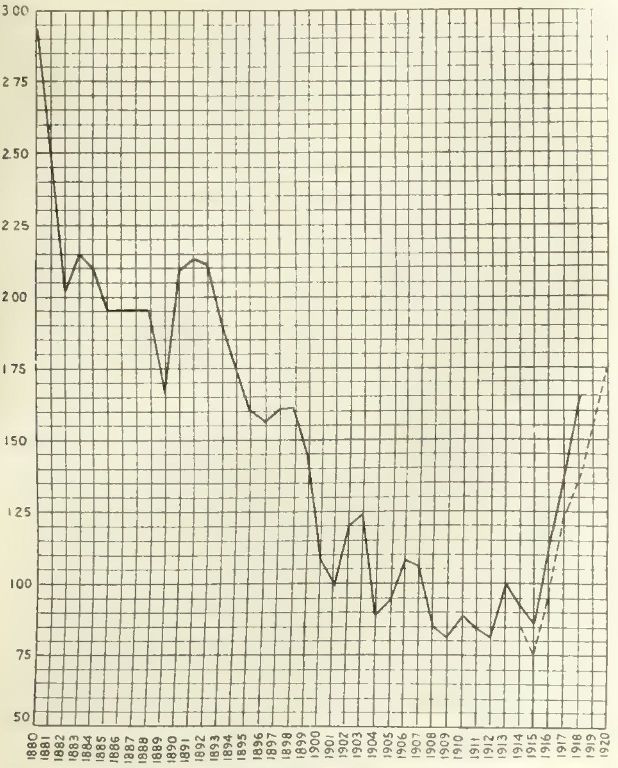
(4) That the most desirable of the deposits of raw mate-

rials have already been acquired by private concerns, and that the states would therefore have to purchase at a high price or else operate a less desirable property at an increased cost.

Other points noted are that it is unsound to attempt to analyze the problem from the viewpoint of political expediency; that market conditions of 1920 and the developments which lead up to them have in some instances been badly misinterpreted as to their bearing upon the advisability of the establishment of public plants; that the price curve of Fig. 2 indicates intense competition in the industry; that a conservative estimate of the capacity of the mills of the United States which is now and has been for several years available is 125,000,000 bbl. annually, but that the greatest annual consumption we have ever had was 94,000,000 bbl., or 75 per cent of capacity in 1916; and that the causes of this condition were as follows:

Prior to the war the reason was lack of demand; during the war it was governmental restriction; and in the last year or two it has been demoralized transportation facilities and the inability of the plants to obtain fuel, supplies, containers, etc., regularly and in sufficient quantity to permit of economical operation. These were conditions over which the private cement plants had no control. They affected all business in much the same manner. Every state highway department, for example, has felt the lack of transportation facilities, and knows that it was due, largely, to embargoes, special service orders, strikes, and the general postwar era of extravagant inefficiency of labor.

To demonstrate the fluctuation in operating conditions, costs of materials, increased cost of transportation, and all of the many items which have entered into the true cost of



RANGE IN AVERAGE FACTORY PRICE PER BARREL OF PORTLAND CEMENT 1880-1920

DOTTED LINE SHOWS AVERAGE FACTORY PRICE OF MILL WHOSE COST FIGURES ARE DISCUSSED IN PAPER.

Fig. 2—Price Range of Portland Cement.

TABLE I—ANNUAL PORTLAND CEMENT MANUFACTURING CAPACITY OF THE UNITED STATES, BY COMMERCIAL DISTRICTS, 1917 AND 1918.

District.	Estimated capacity (barrels). 1917.	1918.	Per cent of capacity utilized. 1917.	1918.
Lehigh district (eastern Pennsylvania and western New Jersey)	37,016,132	36,904,000	66.0	53.4
New York	8,552,480	8,411,400	63.3	48.7
Ohio and western Pennsylvania	9,379,040	12,983,000	78.3	49.6
Michigan and northeastern Indiana	8,672,400	7,770,000	60.7	52.9
Southern Indiana and Kentucky	4,336,200	4,550,000	58.1	35.4
Illinois and northwestern Indiana	13,859,780	14,060,000	78.8	51.0
Maryland, Virginia and West Virginia	4,384,380	4,322,200	71.2	52.7
Tennessee, Alabama and Georgia	4,657,400	4,500,000	78.9	66.5
Iowa, Missouri and Minnesota	13,764,480	14,040,000	85.5	67.5
Nebraska,[1] Kansas, Oklahoma and central Texas	12,197,570	10,579,500	63.2	50.8
Rocky Mountain States (Colorado, Utah, Montana and western Texas)	4,336,200	4,498,000	75.2	50.9
Pacific Coast States (California, Washington and Oregon)	15,594,260	15,783,100	47.3	35.2
	136,750,322	138,401,200	67.9	51.3

[1] Nebraska had no output in 1918.

TABLE III.—COMPARATIVE COSTS PER BARREL.
(Capacity of mill, 2,000 bbl. per day.)

	1914.	1915.	1916.	1917.	1920 (10 mo. to Nov. 1.)
Number of barrels cement manufact'd	401,727	336,918¼	366,376¼	218,814¾	248,152¼
Materials:					
Raw material No. 1	0.05114	0.04670	0.05257	0.06566	0.10993
Raw material No. 2	.05328	.05313	.05482	.07167	.20582
Unground coal	.11034	.10955	.14389	.24098	.46754
Gypsum	.01440	.01647	.01770	.02366	.03966
Sweepings	.00140	.00218	.00172	.00319	......
Composition	.....	.00046	.00028	.. ..	......
Total	.23056	.22849	.27098	.40516	.82295
Labor:					
Operating	.06397	.05467	.06970	.09814	.20566
Repairs & maint'nce.	.01181	.01526	.01720	.03108	.04198
Total	.07578	.06993	.08690	.12922	.24764
Supplies:					
Operating	.....	... ..	... ..	.....	.01449
Repairs & maint'nce.	.04561	.03959	.04294	.05059	.09745
Tools	.00007	.00010	.00013	.00016	.00084
Oil and waste	.00351	.00327	.00353	.00462	.00772
Fuel	.00850	.01146	.01357	.02184	.06225
Total	.05769	.05442	.06017	.07721	.18275
Expenses:					
Power, light & water	.07194	.07070	.09310	.14117	.26203
Laboratory	.00397	.00420	.00383	.00477	.00858
Shops	.00256	.00353	.00446	.00459	.00220
Teaming	.00053	.00081	.00089	.00134	.00149
Mill office	.01195	.01349	.01268	.02026	.01539
Boarding house	.00075	.00034	.00090	.00043	.00317
Welfare work	......	......	......	......	......
Total	.09170	.09307	.11586	.17256	.29286
Provisions for—					
Depreciation and obsolescence	0.10000	.010000	0.09999	0.10000	0.10000
Insurance	.00861	.00919	.01264	.01626	.00778
Taxes	01356	.01479	.01314	.01485	.01002
Contingencies	.01270	.00714	.00891	......	.00364
Packing and loading.	.03500	.03088	.03969	.04923	.08154
Sack handling	.00909	.00623	.00764	.01234	.01495
Total	.17896	.16823	.18201	.19268	.21793
Total mill cost	.63469	.61414	.71592	.97683	1.76413

Note.—None manufactured in 1918 and 1919.

TABLE II—ESTIMATED SURPLUS OR DEFICIENCY IN LOCAL SUPPLY OF PORTLAND CEMENT IN CEMENT-PRODUCING STATES, 1917-18, IN BARRELS.

State or division.	1917 Shipments from mills.	1917 Estimated consumption.	1917 Surplus or deficiency.	1918 Shipments from mills.	1918 Estimated consumption.	1918 Surplus or deficiency.
California	5,659,547	4,608,011	+ 1,051,530	4,238,424	3,606,286	+ 632,138
Illinois	4,378,233	7,189,662	— 2,811,429	3,703,471	4,925,736	— 1,222,265
Indiana	8,148,678	3,425,053	+ 4,723,620	6,205,326	2,406,617	+ 3,798,709
Kansas	3,772,884	1,977,798	+ 1,795,080	2,586,834	1,422,877	+ 1,163,957
Michigan	4,313,771	4,425,533	— 111,762	3,618,088	3,266,393	+ 351,695
Missouri	[illegible]800,988	2,548,152	+ 3,252,836	4,515,695	1,652,454	+ 2,863,241
New Jersey	2,397,069	3,120,589	— 723,520	(1)	(1)	(1)
New York	5,408,726	8,920,808	— 3,512,082	4,074,159	6,319,045	— 2,244,886
Ohio	1,565,394	6,950,672	— 5,385,278	1,289,887	5,010,482	— 3,720,595
Oklahoma	1,736,761	1,443,928	+ 292,833	1,218,841	1,118,595	+ 100,246
Pennsylvania	27,709,442	7,787,055	+19,922,387	22,238,689	6,611,108	+15,627,581
Texas	2,358,944	2,034,548	+ 324,396	1,918,919	1,509,318	+ 409,601
Utah	899,599	526,086	+ 373,513	549,593	350,603	+ 198,990
Washington	1,403,191	1,189,880	+ 213,311	1,116,754	1,044,898	+ 71,856
Maryland, Virginia and West Virginia	[illegible]	4,087,586	978,488	[2]4,362,442	[2]7,650,679	—[2]3,288,237
Tennessee and Kentucky	2,628,388	1,852,770	+ 775,618	2,254,277	1,576,991	+ 677,286
Alabama and Georgia	1,672,173	1,267,030	+ 405,143	1,349,174	1,557,691	— 208,517
Iowa, Minnesota and Nebraska[3]	5,731,652	7,764,443	— 2,032,791	4,196,902	5,564,697	— 1,367,795
Colorado, Montana and Oregon	[illegible]	1,978,624	+ 30,312	1,478,033	1,278,730	+ 199,303
	70,703,474	73,098,228	+17,605,246	70,915,508	56,873,200	+14 042,308

[1] Included with Maryland, Virginia and West Virginia. [2] Includes also New Jersey in 1918. [3] Nebraska had no output in 1918.

cement during the past several years. Tables III and IV are given for two mills of 2,000 and 3,900 bbl. per day capacity, respectively. These mills have operated under the same management from 1915 to date. The company markets a well-known brand under an exceptionally able business management and nas accepted its obligations of fulfilling hold-over contracts from previous years, even at increasing manufacturing unit costs per barrel.

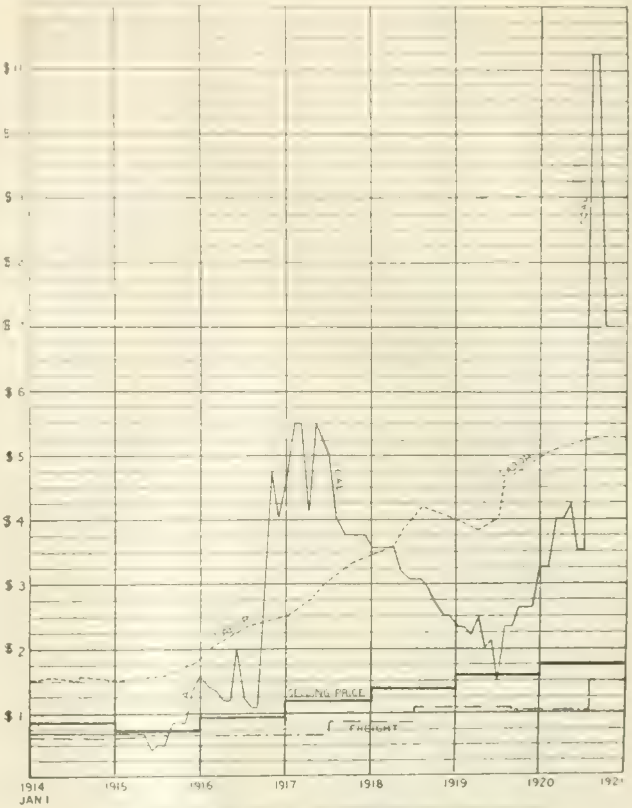
The smaller mill, with the higher unit cost per barrel, was shut down during 1918 and 1919, when the demand was far below production in this country and when we experienced general unsettlement in the construction industry. It will be noted that in the 3,900-bbl. mill the cost of materials jumped from 20.6 ct. per barrel in 1914 to 63 ct. per barrel for the first 10 months in 1920; labor jumped from 6 ct. to 13.7 ct. per barrel; supplies from 6 ct. to 12.7 ct. per barrel; general mill expense from 11.1 ct. to 20 ct. per barrel; reserves and packing costs from 17.5 ct. to 22 ct. per barrel.

A survey of some of the variable items entering into the manufacturing costs is given in Fig. 3. Freight is the average cost per ton from a given manufacturing plant to an assumed destination at a relatively short distance from the mill; the labor curve represents the average price of common labor employed at the mill; the coal cost represents quotations at mines or of spot coal during the tight period of midsummer, 1920. The curve of selling price of cement is taken from the mill referred to in Tables III and IV.

Table V shows combined totals, unit costs and selling prices for the two mills. The sales appear to have included considerable amounts held in storage or supplied by other mills of the same company.

In Table VII are given Mr. Hilts' estimates of the costs of first class and second class state-owned plants. The conditions in which these estimates are based are as follows:

(1) A first-class cement plant of 600,000 bbl. capacity per year, assuming an operation period of 350 days per year. The plant is to be so designed that there will be minimum maintenance requirements, and to be equipped with raw materials, storage bins, up-to-date dust-collecting systems, waste-heat boilers, a central generating plant with all machinery supplied with unit electric-driven motors. It is further assumed that a sanitary system, a pumping station, and



LABOR COST-COST PER DAY. TRANSPORTATION COST-COST PER TON COAL COST-[illegible] PER TON SELLING PRICE PER BARREL OF CEMENT OF MILL QUOTED IN FIGURES NOS 18 AND 19

Fig. 3—Factors in Cost of Portland Cement Production.

TABLE IV.—COMPARATIVE COSTS PER BARREL.
(Capacity of mill, 3,900 bbl. per day.)

	1914.	1915.	1916.	1917.	1918.	1919.	1920 (10 mo. to Nov. 1)
Number of barrels of cement manufactured	355,260	491,239¾	596,081	634,252	705,099½	847,709¾	646,931¾
Materials:							
Raw material No. 1	0.05300	0.05026	0.05756	0.07579	0.08053	0.08074	0.11441
Raw material No. 2	.03023	.04242	.05462	.03882	.05362	.06014	.09159
Unground coal	.10599	.10418	.13594	.21843	.24705	.20224	.38034
Gypsum	.01647	.01474	.01681	.02131	.02672	.03069	.04187
Sweepings	.....	.....	.....	[illegible]	.00131	.00096	.00194
Total	.20569	.21160	.26493	.35467	.40923	.37477	.63015
Labor							
Operating	.04467	.04170	.04456	.05990	.07352	.07675	.10885
Repairs and maintenance	.01686	.01568	.01577	.02110	.02066	.02341	.02864
Total	.06153	.05738	.06033				
Supplies:				.08100	.09418	.10016	.13749
Operating	.....	.....	.....	.....	.....	.....	.00996
Repairs and maintenance	.04752	.04553	.04298	.04532	[illegible]	.06186	.07290
Tools	.00008	.00013	.00048	.00036	.00030	.00028	.00023
Oils and waste	.00448	.00456	.00437	.00471	.00672	.00821	.00798
Fuel	.00767	.00780	.00865	.01388	.01399	.01389	.03588
Total	.05975	.05802	.05648	.06427	.08106	.08424	.12695
Expenses:							
Power, light and water	.09533	.06623	.07390	.10696	.16358	.13091	.16242
Laboratory	.00354	.00313	.00312	.00322	.00585	.00899	.01094
Shops	.00290	.00225	.00301	.00345	.00642	.00380	.00315
Teaming	.00018	.00002	.00029	.00013	.00064	.00024	.00001
Mill office	.00913	.00990	.01020	.01494	.01959	.02037	.01987
Boarding house	.00052	.00022	.00093	.00072	......	......	......
Welfare work		....	......	.....	.....	......	.00429
Total	.11160	.08175	.09145	.12942	.19608	.16431	.20068
Provisions for							
Depreciation and obsolescence	.10000	.10000	.10000	.10000	.10000	.10000	.10000
Insurance	.00681	.00652	.00945	.01357	.01693	.01419	.01230
Taxes	.01094	.01047	.00969	.01132	.01691	.01652	.01469
Contingencies	.01316	.01344	.00814	.01565	.01349	.01176	.00243
Packing and loading	.03500	02731	.03157	.03821	.04274	.04952	.07664
Sack handling	.00901	.00455	.00587	.00425	.00957	.01239	.01376
Total	.17492	.16229	.16472	.18300	.19964	.20438	.21982
Total mill cost	.61349	.57104	.63791	.81236	.98019	.92786	1.31509

TABLE V.—SUMMARY OF MILL COST AND OVERHEAD.

	1914.	1915.	1916.	1917.	1918.	1919.	1920 (10 months)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	705,099½	847,709¾	895,084
Barrels sold (including foreign)	839,584¼	852,099	964,286	933,423	706,837½	893,969½	906,655
Mill cost	0.62474	0.58857	0.66760	0.86627	0.98019	0.92786	1.43958
Overhead (including selling, administration, financial)	.18253	.17543	.19338	.20225	.22805	.29129	.20733
Total cost	.80727	.76400	.86098	1.06852	1.20824	1.21915	1.64691
Average selling price received	.59650	.75140	.96668	1.23709	1.36995	1.54509	1.75422

a cement stock house of 150,000 bbl. capacity, a main office building, dispensary, and sufficient trackage to facilitate train movements, both from and to the mill, will be required. It is further assumed that the mill will be located on property purchased by the state on which there is a sufficient raw material supply to run the plant from 50 to 100 years. The estimates to include, also, general items which are necessary in financing the construction, with sufficient capital to be laid aside to operate the plant for one month. The operation expenses are to include sufficient sack supply for three months' operation.

(2) A second-class plant of the same capacity built with a view to detailed structural maintenance from time to time, and with dust-collecting systems, sanitary system, dispensary, etc., eliminated.

Such an estimate is given in detail in Table VII. This estimate is for plants which will be erected on the assumption that the state believes that the demand for cement has become stabilized and that the industry is one of the major construction industries; that the plant must be prepared to turn out cement which will be subject to intense competition, and therefore, be manufactured at the lowest possible mill cost. This estimate is for a contemplated plant in the north central or northeastern part of our country. The total cost per barrel of production for plant No. 1 is estimated to be $4.865 per barrel; for plant No. 2, $3.483 per barrel.

In order to operate these plants, it is assumed that the inventory given in the table will be necessary. This inventory amounts to $0.365 per barrel capacity. The total cost of construction and inventory is, therefore, $5.23 per barrel capacity for plant No. 1 and $3.848 per barrel capacity for plant No. 2.

TABLE VI.—LABOR EFFICIENCY IN 51 CEMENT PLANTS, ON MAN-HOURS PER BARREL BASIS, FOR THE YEAR 1919.

Plant No.	Number of barrels produced.	Number of man-hours per barrel produced.	Number of barrels shipped.	Number of man-hours per barrel shipped.			Number of shifts in plant.
				Packing and loading.	Sack handling.	Total.	
1	855,463	0.643	932,145	0.065	0.047	0.112	3
2	919,192	1.022	981,072	.102	.029	.131	2
3	406,000	.683	483,450	.046	.034	.080	2
4	281,811	1.349	284,686	.097	.023	.120	2
5	645,870	.523	657,870	.055	.027	.083	2
6	400,000	.545	344,000	.045	.022	.067	3
7	601,333	.888	611,359	.066	.061	.127	2-3
8	1,414,000	.590	1,638,582	.114	.054	.168	3
9	225,118	.814	182,838	.079	.031	.110	3
10	660,000	.840	650,000	.062	(1)	.062	2
11	352,130	1.195	417,896	.073	.019	.092	2
12	200,521	1.683	189,668	.115	.058	.173	2
13	498,816	1.257	608,707	.106	.080	.186	2
14	278,300	.947	270,300	.072	.046	.118	2
15	547,771	.999	549,310	.083	.120	.203	2
16	498,781	1.006	571,055	.071	.021	.092	2
17	838,056	.707	998,676	.072	.027	.099	2
18	148,692	1.617	180,688	.087	.025	.112	2
19	234,557	1.109	227,953	.066	.033	.099	2
20	697,286	.892	707,836	.059	.071	.130	2
21	176,245	.938	179,928	.065	.034	.099	2
22	790,583	.940	758,744	.113	[1].005	.118	2
23	1,182,971	.572	1,282,680	.068	[1].001	.069	2
24	265,830	1.429	370,652	.092	[1].008	.100	2
25	513,448	1.020	565,092	.100	[1].008	.108	2
26	847,710	.644	878,092	.061	[1]....	.061	2-3
27	639,535	.638	659,642	.049	.016	.065	2
28	327,065	.649	355,977	.035	.028	.063	2
29	878,266	1.150	871,966	.067	.034	.101	2
30	1,118,625	.551	1,121,400	.082	.079	.161	2-3
31	326,954	1.038	357,304	.090	.045	.135	2
32	514,309	.920	496,552	.143	.066	.209	2-3
33	377,000	.699	379,011	.061	.067	.128	2-3
34	594,000	.737	649,384	.058	.034	.092	2-3
35	717,410	.840	742,641	.068	.074	.142	2-3
36	768,755	1.088	946,672	.099	.027	.126	2
37	656,469	1.047	664,224	.099	.065	.164	2
38	1,671,125	1.006	1,563,161	.135	.078	.213	3
39	532,354	1.351	643,535	.066	.078	.144	3
40	1,291,730	.789	1,391,096	.084	.062	.146	3
41	1,103,013	.970	1,466,398	.110	[2]....	.110	2
42	1,099,399	.642	1,299,500	.064	.044	.108	3
43	1,289,482	.567	1,541,340	.041	.011	.052	3
44	698,601	.833	867,526	.042	.005	.047	3
45	311,118	1.551	347,481	.037	.010	.047	2
46	641,488	1.091	705,825	.046	.010	.056	2
47	628,386	1.309	663,509	.158	.018	.206	3
48	194,153	.896	261,120	.047	.055	.102	3
49	333,483	.879	338,278	.085	.045	.130	2
50	1,249,500	.632	1,245,308	.057	[1]	.057	2
51	390,729	.802	429,984	.048	.024	.072	2

[1]Bags cleaned by contract. [2]Man hours not given.

TABLE VII—ESTIMATE OF COST OF A 600,000-BARREL CEMENT PLANT (DEC. 9, 1920.).

	First-class plant—estimate.	Second-class plant—estimate.
General mill expense:		
Clearing, grading, and filling	$ 5,000	$ 3,000
Clock house and watchman's shanty	10,000	6,000
Fence, inclosing mill property	10,000	5,000
Total	$ 25,000	$ 14,000
Construction equipment:		
Tools and equipment	50,000	15,000
Temporary buildings	7,500	2,500
Temporary tracks	7,500	2,500
Total	$ 65,000	$ 20,000
Trestle to raw-material bins:		
Excavating and back filling	3,000	1,500
Foundations	10,000	2,000
Trestle	50,500	20,000
Walks	1,500	500
Total	$ 65,000	$ 24,000
Raw-material bins:		
Excavating and back filling	1,500	500
Foundations and floor	5,000	1,000
Building	37,000	7,000
Roof	3,500	1,500
Concrete walls and plastering	13,000	2,000
Total	$ 60,000	$ 12,000
Raw-material mill:		
Excavating and back filling	5,000	2,500
Foundations and floor	30,000	15,000
Building, hoppers, and upper floors	65,000	30,000
Roof	6,000	2,500
Walls, plastering, doors and windows	15,000	5,000
Crushing machinery	7,000	7,000
Driers, stacks, and coal-burning apparatus	36,000	35,000
Dust-collecting system for driers	15,000	15,000
Preliminary grinding machinery	36,000	36,000
Tube mills	70,000	70,000
Elevating and conveying machinery	40,000	25,000
Dust-collecting system for machinery	15,000	15,000
Total	$ 340,000	$ 258,000
Raw-material storage bin:		
Excavating and back filling	2,000	1,200
Foundations, tunnels, and floors	4,000	2,000
Building	10,000	6,000
Roof	500	300
Concrete walls and plastering	7,500	2,500
Elevating and conveying machinery	6,000	6,000
Total	$ 30,000	$ 18,000
Gypsum storage:		
Excavating and back filling	500	200
Foundations and floors	2,000	600
Building, walls, and plastering	10,000	3,000
Roof	500	200
Elevating and conveying machinery	3,000	3,000
Total	$ 16,000	$ 7,000
Cement stock house (150,000 barrels capacity):		
Excavating and back filling	8,000	5,000
Foundations, tunnels, and floor	75,000	50,000
Building and hoppers	20,000	15,000
Concrete walls and plastering	142,000	60,000
Elevating and conveying machinery	30,000	30,000
Packing and loading machinery	15,000	15,000
Dust-collecting system	10,000	10,000
Total	$ 300,000	$ 185,000
Sack-storage building:		
Excavating and back filling	2,000	500
Foundation and floor	12,000	6,500
Building, walls, and plastering	25,000	15,000
Heating, lighting, and sanitary system	6,000	5,000
Bag-cleaning machinery	15,000	15,000
Dust-collecting system	15,000	13,000
Total	$ 75,000	$ 55,000
Machine and blacksmith shop:		
Excavating and back filling	500	200
Foundation and floor	5,500	3,000
Building	18,000	8,000
Roof	3,000	1,000
Walls, plastering, doors, and windows	8,000	4,000
Heating and sanitary system	8,000	6,800
Machinery and equipment	17,000	17,000
Total	$ 60,000	$ 40,000
Coal bins:		
Excavating and back filling	500	100
Foundations and floors	2,000	1,000
Building	16,000	8,000
Roof	500	300
Concrete walls, bin floor, and plastering	6,000	3,600
Total	$ 25,000	$ 13,000
Coal-grinding building:		
Excavating and back filling	1,500	500
Foundations and floors	8,000	3,000
Building and hoppers	16,000	10,000
Roof	1,500	500
Crushing and drying machinery	12,000	12,000
Pulverizing machinery	14,000	14,000
Dust-collecting system	9,000	8,000
Elevating and conveying machinery	8,000	8,000
Total	$ 70,000	$ 56,000
Burner building:		
Excavating and back filling	3,000	1,000
Foundations and floor	15,000	8,000
Building, hoppers, and upper floors	35,000	25,000
Roof	3,500	1,000
Walls, plastering, doors, and windows	11,000	6,000
Two 10 by 150 ft. kilns and stack bases	100,000	80,000
Dust-collecting system for kilns	105,000	....
Elevating and conveying machinery	17,500	17,000
Total	$ 290,000	$ 138,000
Waste-heat boiler house:		
Excavating and back filling	1,500	500
Foundation and floors	7,500	3,500
Building and upper floors	19,000	10,000
Roof	500	300
Walls, plastering, doors, and windows	7,500	3,500

[illegible] boilers and superheaters ([illegible] [illegible] installed)	90,000	90,000
Flues to and from boilers and fans	7,500	7,500
Fans, motors, and switches	16,000	16,000
Boiler feed pumps, motors, and switches	7,500	7,500
[illegible]	[illegible]	[illegible]
Boiler-feed water, filtrating, and softening plant	5,000	5,000
[illegible]	4,500	3,000
Steam line, supports, and covering	23,500	20,200
Total	$ [illegible]	$ 175,000
Storeroom:		
Excavating and back filling	[illegible]	100
Foundation and floor	2,500	1,500
Building, walls, and plastering	9,000	6,000
Equipment	3,000	2,400
Total	$ 15,000	$ 10,000
Sanitary installations:		
Excavating and back filling	500	....
Foundation and floors	5,000	....
Buildings	12,500	....
Roofs	2,000	....
Walls, plastering, doors, and windows	7,000	....
Plumbing, lighting, and heating systems	8,000	5,000
Total	$ 35,000	$ 5,000
Main office, foremen's office, and dispensary:		
Excavating and back filling	[illegible]	500
Foundation and floors	10,000	3,500
Building, walls, plastering, doors, and windows	40,000	10,000
Heating, lighting, and plumbing system	3,000	2,000
Furniture and fixtures	10,000	8,000
Total	$ 65,000	$ 24,000
Compressed-air system:		
Air compressor and motor	4,500	4,500
Air receiver and piping	4,500	4,500
Total	$ 9,000	$ 9,000
Track system—Tracks	120,000	100,000
Drainage and sewer system	10,000	3,000
Quarry:		
Steam shovels	30,000	20,000
Quarry cars and dinkey locomotive	55,000	40,000
Crushing plant, complete	90,000	90,000
Total	$ 175,000	$ 150,000
Generating station:		
Excavating and back filling	3,000	1,200
Foundations and floor	12,000	5,500
Building and upper floors	19,000	11,000
Roof	1,500	500
Walls, plastering, doors, and windows	12,000	8,000
Motor generator	6,000	6,000
Sanitary facilities	500	300
Turbo-generator and exciter (two 1,000-kw. ordin.; one 1,000-kw., spare)	85,000	85,000
Condenser and accessories	10,000	10,000
Condenser piping	9,000	8,500
Air washer	2,000	2,000
Transformers	15,000	15,000
Main switches, switchboard, and wiring	15,000	15,000
Total	$ 190,000	$ 168,000
Electrical work outside station:		
Trenching and back filling	2,000	500
Concrete work and wire ducts	18,000	11,500
Wiring	35,000	25,000
Total	$ 55,000	$ 37,000
Pumping station:		
Excavating and back filling	500	100
Foundation and floors	2,500	1,500
Building	3,000	2,000
Roof	250	150
Walls, plastering, doors, and windows	1,500	1,000
Pumps, motors, and switches	6,000	6,000
Water piping, valves, and fittings	24,000	20,000
Screens	2,250	2,250
Total	$ 40,000	$ 33,000
Clinker storage:		
Excavating and back filling	3,500	1,000
Foundations, retaining walls, and floor	22,500	15,000
Crane runway	15,000	12,000
Clinker cranes, with grabs	34,000	34,000
Total	$ 75,000	$ 62,000
Finishing mill:		
Excavating and back filling	2,500	1,000
Foundations and floor	20,000	12,000
Building, hoppers, and bridge to stock house	60,000	45,000
Roof	2,500	1,000
Walls, plastering, doors and windows	15,000	10,000
Preliminary grinding machinery	35,000	35,000
Tube mills	70,000	70,000
Elevating and conveying machinery	30,000	30,000
Dust-collecting system	25,000	20,000
Total	$ 260,000	$ 224,000
Plant property:		
Stone property, 150 acres; shale property, 50 acres; plant property, 50 acres	125,000	125,000
Total	$2,795,000	$1,965,000
General works expense	$ 30,000	$ 30,000
Engineering	45,000	45,000
Contingencies	25,000	25,000
Accident and hospital reserve	25,000	25,000
General overhead expense, 4.5 per cent	$ 125,000	$ 125,000
Grand total	$2,920,000	$2,090,000

$2,920,000 divided by 600,000 equals $4.865 per barrel (first-class plant).

$2,090,000 divided by 600,000 equals $3.483 per barrel (second-class plant).

Estimated cost of these cement plants having a yearly capacity of 600,000 barrels, based on 350 days' operation and on the supposition that the plant site is level ground with water and railroad facilities adjacent to the site. The above first-class plant is equipped with all modern and up-to-date improvements such as waste-heat boilers, dust-collecting apparatus throughout, and modern sanitary facilities.

INVENTORY NEEDED IN THE OPERATIONS OF A 600,000 BARREL CAPACITY PLANT.

	First-class plant—estimate.	Second-class plant—estimate.
600,000 sacks at $1.50 per thousand (6 months' supply)	$ 90,000	$ 90,000
Stores and miscellaneous supplies	40,000	40,000
2,500 tons coal at $5 (1 month's supply)	12,500	12,500
250 tons gypsum at $7 (1 month's supply)	1,750	1,750
Raw material, limestone, shale, or clay	5,000	5,000
10,000 barrels clinker (average monthly inventory $1)	10,000	10,000
40,000 barrels cement (average monthly inventory $1.50)	60,000	60,000
Total	$219,250	$219,250

TABLE VIII MORTALITY TABLE, BEING AVERAGE ESTIMATED LIFE OF VARIOUS PROPERTIES IN THE CEMENT INDUSTRY.

	Average life (years).
Machinery—	
Quarry:	
Locomotive	13
Tracks and cars	9
Steam shovels	11
Dredges	11
Drills—Well	9
Drills—Tripod	7
Live stock	8
Carts and wagons	7
Cableway	9
Raw department:	
Crushing machinery	14
Driers—Upright	11
Driers—Rotary	11
Slurry tanks	16
Grinding machinery	13
Clinker-burning department:	
Kilns	13
Coolers—Upright	12
Coolers—Rotary	13
Clinker-grinding machinery	12
Coal mill:	
Driers	11
Grinding machinery	14
Power house:	
Boilers	15
Engines	17
Generators	16
Motors	14
Stock-house machinery	10
Machinery and B. S. shop machinery	15
Buildings—	
Mill:	
Concrete	50
Steel and corrugated iron	20
Steel and stucco	21
Steel and brick	30
Timber	20
General (mill office, laboratory, storehouse, etc.):	
Concrete	50
Steel and corrugated iron	20
Steel and stucco	22
Steel and brick	30
Frame	18
Frame and stucco	22
Dwellings:	
Concrete	50
Brick	30
Frame	20
Frame and stucco	23

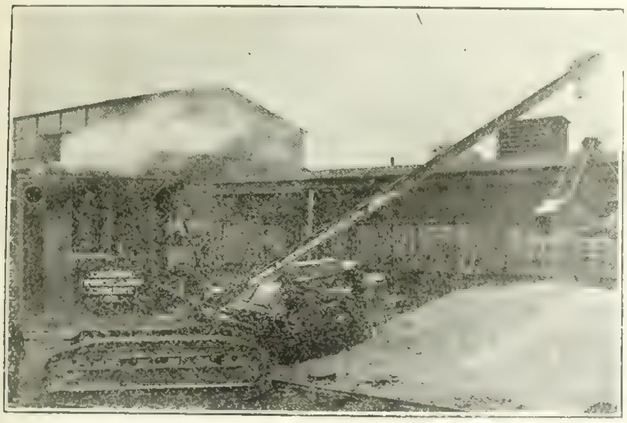
TABLE IX—ESTIMATED OPERATING COSTS PER BARREL MANUFACTURED BY THE FIRST-CLASS PLANT OF TABLE VII OPERATING $.. DECEMBER, 1920.

Raw Material:	
No. 1	$0.11
No. 2	0.15
Gypsum	0.05
Total	$0.31
Labor:	
Operating	$0.21
Repair	0.05
Total	$0.26
Supplies:	
Operating	$0.02
Repair	0.10
Total	$0.12
Fuel:	
Drying raw material	$0.06
Burning clinker	0.47
Total	$0.53
Power, light and water	0.15
Direct cost of production	$1.37
Mill Overhead:	
Superintendence	$0.01
Mill, office and stores	0.02
Laboratory	0.01
Miscellaneous	0.05
Total	$0.09
Reserves:	
Insurance	$0.01
Taxes	0.01
Depreciation	0.10
Total	$0.12
Total bin cost	$1.58

Profit and Loss:	
Sack cost:	
Packing and loading	[illegible]
Sack handling	[illegible]
Cost on board cars	$1.68
Selling expenses	.12
General expenses	[illegible]
Financial expenses	[illegible]
Total costs	$1 [illegible]

New Crawling Tread Locomotive Crane

A new crawling tread locomotive crane has been placed on the market by the Orton & Steinbrenner Co., Chicago. Two sizes of cranes are made in the new design, both being especially adapted to contractor's use; they are rated as 7 tons and 12 tons capacity. The 7-ton size is used by contractors for excavating and road work and also in coal, sand and gravel yards. The crane is entirely constructed on the interchangeable duplicate part system which makes repairs immediately available. The details of construction are very simple and rugged. The crawling tread is developed from an improved form of that used on government tanks during the European war. The tread links and sprockets are of cast steel of ample size and the chain idler rollers are bronze bushed with patented pressure system of lubrication. Each crawling tread is supported on bottom between drive spocket and idler by four pairs of idler rollers. Each pair of idler rollers is carried in equalizing strut backed by heavy coil spring and when traveling over obstacles such as rails, road tracks, etc., rollers will tilt as much as 6 in. from the horizontal. It is claimed the crane will travel up grades of 20 to 30 per cent in soft material. Tread links are reversible and the crane can travel with equal facility either forward or backward. Links are so designed that ends overlap and no foreign material can enter the spaces between. Surface area of crawling tread is great enough to reduce unit pressure on ground to 10 lb. per square inch—although crane weighs in the neighborhood of 45,000 lb.

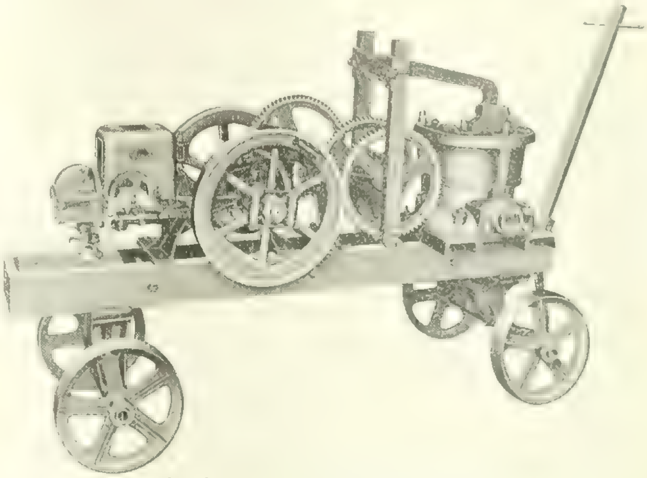


New "O. S. Dependable" Crawling Tread Locomotive Crane.

The sprocket is driven by steel bevel gears and steel shafting from a countershaft of the hoist. No chain drive is used. The car body and turntable of the machine are fabricated of structural steel shapes and plates, amply braced and thoroughly riveted. The turntable revolves on twelve chilled tread rollers on a Tee rail section of large diameter. The hoisting mechanism is designed mainly with a view to accessibility. The hoist proper consists of four main horizontal power shafts driven through a train of cast steel cut spur gears and three auxiliary vertical shafts driven by cast steel bevel gears, these transmitting the power for the four principal functions of the crane—hoisting the load, swinging it, raising and lowering the boom and traveling. Any one function may be operated independently of the others or all may act together. For operating bucket double automatic drums are regularly supplied. The engine is of the double cylinder horizontal non-reversing type. Cylinders are 6 in. in diameter by 8 in. bore in the 7 ton size and 7 in. by 9 in. in the 12 ton size. Boiler is of the vertical fire tube full length flue type of ample capacity for steaming requirements and is built to conform to the specifications of the A. S. M. E. Steering of the crane is manipulated by the operator from the cab by means of brakes on the differential shaft. It is stated that the crane can be turned completely around in any one spot or in a circle with radius about equal to its own length. The standard 7 ton crane is equipped with 30 ft. boom; standard 12 ton is equipped with 35 ft. boom, but extra lengths may be supplied. Crane can be arranged to operate on broad faced road wheels or on standard or special gage rail tracks besides crawling tread.

Trench Pumping Outfit

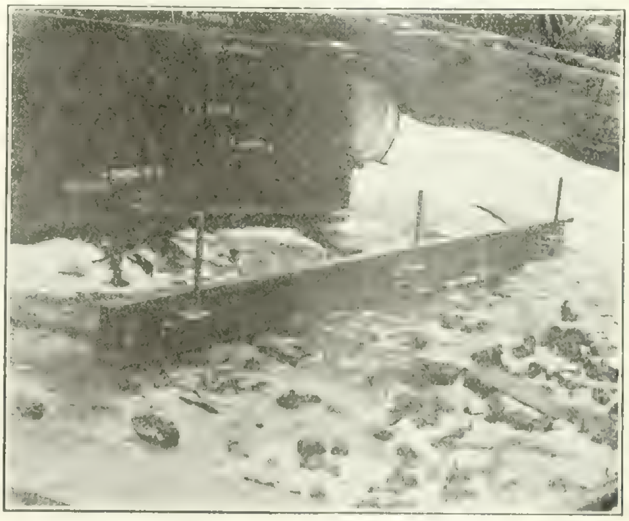
A diaphragm pump outfit designed specially for sewer, tunnel and foundation work is illustrated. The outfit consists of a 1¾ HP. Jumbo engine with Webster magneto, a cut geared pumping jack and diaphragm pump, all mounted on a cart, or if preferred, on channel steel skids. The pumping capacity is about 2,500 gal. per hour. The Jumbo engine has a specially designed mixer, which gives a perfect, uniform fuel supply with either kerosene or gasoline. An auxiliary valve does away with the fuel pump and keeps plenty of fuel in the mixer. The pumping outfit is made by the Nelson Bros. Co., 1510 Owens St., Saginaw, Mich., who also make the Jumbo engines. The latter can be obtained in sizes from 3 to 12 HP. in the kerosene throttling governor type and from 1¾ to 7 HP. in the gasoline hit and miss type.



Jumbo Trench Pumping Outfit.

New Steel Form for Concrete Road Construction

After three years' development work a new steel form for concrete road construction has been brought out by the Lakewood Engineering Co., Cleveland, O. This new Lakewood-Hotchkiss form is furnished in sections 10 ft. long, and in the heights for road thicknesses of 5, 6, 7, 8 or 9 in. The distinguishing feature of the design is that a somewhat lighter metal has been used for the main section of the form, but this section has been reinforced by stiffening members, advantageously placed. Each 10-ft. section has the top flange supported

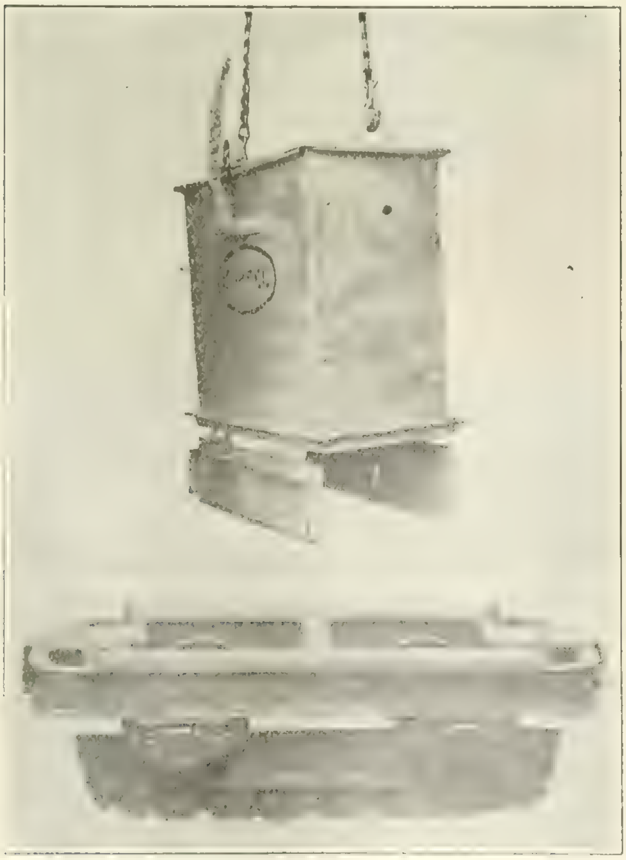


New Lakewood-Hotchkiss Road Form.

at five intermediate points by a heavy stiffening iron. Electric spot welding is used in addition to riveting to fasten the various members of the form together. The top flange is 2¼ in. wide, and turndown section of the top is 1¾ in. deep. The forms are staked to the ground with three stakes to each 10-ft. section. The stake pockets have elliptical holes giving considerable leeway when driving the stake, so that it does not disturb the alignment of the forms. After the stake has been driven until its head is about 1½ in. below the top of the form, so that the stakes will not interfere with the finishing machine wheels, the form is clamped to the stake by a heavy wedge member sliding in the stake pocket. This wedge is heavy enough to allow driving with a sledge hammer. It has a ¼-in. bearing on the stake, and cannot become bent or rapidly worn. These wedges may, however, be easily replaced when worn. They are held in the pockets and cannot become lost on the job. The forms are built so that any section may be removed from a line of forms set up to allow passage of trucks or other contractors' tools. There is an extra heavy slide, at the joint, which holds the forms in alignment, both laterally and vertically, and assures a smooth joint between the forms over which the finishing machines may run. These slides are so located as to be accessible for driving with hand hammer when setting up or taking down the forms. The top of this slide accurately fits into the channel shaped head of the road form. There are no rivets in the top flanges of the form. The sections of form are made from steel especially milled to size for each height of form.

Batch Box and Batch Box Cars

A new batch box and batch box car brought out recently by the Koppel Industrial Car & Equipment Co., Koppel, Pa., is illustrated. The capacity of the box shown is 26 cu. ft. The company also makes boxes of this kind up to 54 cu. ft. capacity. It should be noted that the box has a cement compartment; this was not in place when the photograph was taken. Some particulars of the box follow:



Koppel Batch Box and Oval Type Batch Box Car.

[illegible] hearth steel throughout, flanged at top to [illegible]

Side plates are flanged for connection to end plates.

Side [illegible] angles at bottom, [illegible] in. angle.

[illegible] 2½x2½x¼ in. angle.

Inside vertical stiffener at lever side only—1¾ in. x 1¾ in. x ¼ in. angle.

Lifting eyes—2x⅜ in.

Length inside—4 ft.

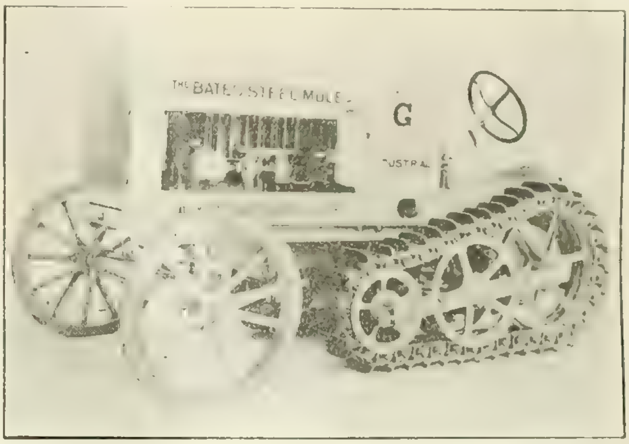
Width inside, 2 ft.

Height inside—3 ft. 3 in.

The car shown is the oval type. A square frame type also is made. These cars are made of 6-in. ship channel underframe, weighing 12 lb. per foot, with 2½-in. (about) flange. The difference between the oval type car and the square type is that the first mentioned is equipped with continuous spring draft gear running the entire length of the car, each car having two springs behind the bumper plate. The bumper plate is made of ½-in. material. The pedestal on the bearing is rivted to the web of the side sill. Both types of cars are equipped with double spring suspended caged roller bearings.

New Tractor

A tractor built for industrial work exclusively is illustrated. This is known as the Model "G" Bates steel mule. It is made so that a power-driven winch can be attached to the front end for logging and other work. It weighs approximately 6500 lb. and has a rating of 25-H.P. on the draw-bar and 35-H.P. on the belt. Like the Model "F" Bates Steel Mule, all working parts are incased against dust and run in oil bath. Wheels, transmission, and crawlers are full roller bearing throughout. The clutch is hand-operated, dry plate disc type and can be operated either from the driver's seat or from the platform of the tractor. The driver's seat is made on a swivel so that it can be pushed out of the way for holding either crawler still when the driver stands on the platform. The pedals for holding either crawler still are located on the platform at rear of tractor. Hauling speeds are 2½ miles per hour, and 3½ miles per hour and the reverse speed is approximately 2 miles per hour. The general construction is of the backbone type where the transmission is bolted directly to the motor, making one solid block of the entire power plant. The motor has a 3-in. hollow crank shaft and a 4½-in. cylinder. The oil pressure carriage is between 35 and 50 lb. and is also regulated that whenever the pull increases on the draw-bar, the volume of oil to the motor bearings is automatically increased at the same time.

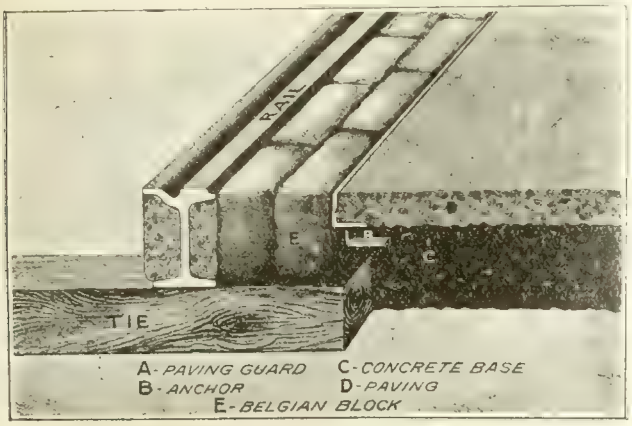


Model G, Bates Steel Mule, Industrial Tractor.

Larger Cities Spent More than They Received in 1919.—Governmental costs, including interest and outlays for permanent improvements, for the 227 cities of the country with a population of 30,000 or more, exceeded total revenues by $8,991,000 in the year 1919, according to statistics on municipal finances made public last month by the Census Bureau. Deducing the item of permanent outlays, however, revenues, which aggregated $1,224,112,000 or $35.32 per capita, exceeded governmental costs by $255,902,000, it was shown. Revenue receipts exceeded current governmental expenses and interest in all but four cities of the group, the figures showed, while in 117 cities revenues exceeded all expenditures, including permanent outlays. The total net indebtedness of the group was placed at $2,679,551,000, or $77.82 per capita, with that of New York City alone, $1,009,809,000, amounting to more than one-third of the total.

New Paving Guard for Street Railways and Roadways

A new paving guard designed to protect pavement adjacent to street railway track from the wave motion of the rails, and for use as an edging for roadway pavements, is illustrated below. The guards are made for any depth of paving and are furnished in straight lengths of 15 ft. or to a radius as required. The anchors are a part of the guard itself being punched from the metal at 2-ft. centers and are 10 ins. in length, bent downward and then twisted so as to extend laterally or transversely to the width of the leg portion. By thus punching the anchors from the center of the horizontal leg and leaving the outer edge intact, a resisting leverage is provided throughout the entire width of the horizontal leg. This is an important feature of the guard, since comparatively narrow angles can be employed and at the same time insure stability of the guard so as not to rock or turn when it is placed in position. The guards are made by H. U. Boureau & Co., 3302 Ludlow St., Philadelphia, Pa.



Boureau Paving Guards.

Personals

John A. Baird has resigned as city engineer of Sarnia, Ont.

James J. O'Connor has been appointed superintendent of streets of Holyoke, Mass.

Lloyd M. Ross has been appointed county highway engineer of Mecklenberg County, North Carolina.

George W. Lanstrum, Helena; H. A. Templeton, Great Falls, and Henry Good, Kalispel, have been named by Gov. Dixon as the new state highway commission of Montana.

C. O. Dowdell, formerly assistant general manager of the Security Cement & Lime Co., Hagerstown, Md., has been placed in charge of field promotion work of the Central Bureau of the National Lime Association.

Thurman W. Dix, assistant professor in the University of Vermont, has been appointed state highway commissioner of Vermont. Mr. Dix formerly was county engineer of Madison County, New York, and he also has been in the service of the New York State Department of Highways.

Samuel Humes, formerly county engineer of King County, Washington, has opened offices at 319 Lyon Bldg., Seattle, Wash., under the firm name of Samuel J. Humes & Co., civil and consulting engineers, specializing in surveys, estimates, municipal improvements, road and bridge construction.

H. C. Nutting, manager of the Pittsburgh Testing Laboratory, Cincinnati, O., for the past six years, has recently organized a new company under the name of the H. C. Nutting Co., at Hunt and Broadway, Cincinnati, O. Mr. Nutting is highway engineer for the Cincinnati Automobile Club and will specialize on highway inspection.

R. E. Caldwell, of the firm of Caldwell & Richards, civil engineers, Salt Lake City, Utah, has been appointed state engineer of Utah. He succeeds George F. McGonagle, who has occupied the post four years. Mr. McGonagle and C. J. Ulrich, assistant state engineer for ten years, will open offices in the Deseret National Bank Bldg., Salt Lake City, and enter into private business.

Gunni Jeppesen, structural engineer of the Leonard Engineering Co., has joined the Chicago Bascule Bridge Co., Chicago, as associate engineer. Mr. Jeppesen is a graduate of the State Polytechnical Institute at Copenhagen, Denmark. He was connected with the Strauss Bascule Bridge Co. for twelve years, from its inception until 1917, and since then has been engaged in industrial plant work with the Leonard Engineering Co.

Johnson & Benham, Inc., consulting engineers, of New York and Kansas City, Mo., announce the reorganization of the business. All contracts and business of the New York office have been taken over by George A. Johnson Co., Inc., the members thereof being George A. Johnson, Harold C. Stevens, Nelson B. Wolfe, Charles R. Wyckoff and Harry B. Joyce. The main offices of the corporation are at 150 Nassau street, New York City. All contracts and business of the Kansas City office have been taken over by Benham & Mullergren, a partnership consisting of Webster L. Benham and Arthur L. Mullergren, with offices eighth floor Firestone building, Kansas City, Mo.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Street Cleaning Equipment.—Elgin Sales Corporation, 501 Fifth Ave., New York City. Circular illustrating and describing motorized street cleaning equipment.

Concrete Mixers.—New Way Manufacturing Co., Eau Claire, Wis. 16 page catalog containing description, illustrations and specifications of the New Way Mixers.

Dragline Cableway Excavators.—Sauerman Bros., Chicago, Ill. 16 page pamphlet illustrating and describing uses of this equipment in connection with sand and gravel plants.

Road Building.—Lakewood Engineering Co., Cleveland, O. Booklet describing the 280-mile road job now being carried out in Maricopa County, Arizona, by Twohy Bros., contractors.

Road Culverts.—Klauer Manufacturing Co., Dubuque, Ia. Circulars on corrugated road culverts. One type has supporting flange to keep the earth from washing away ends of the culvert.

Road Building Equipment.—Galion Iron Works & Mfg. Co., Galion, O. 52 page catalog illustrating and describing the Galion culvert pipe, car unloaders and other equipment for road builders.

Drawing Instruments.—C. F. Pease Co., 813 North Franklin St., Chicago, Ill. 8-page booklet giving illustrations and prices of complete sets of Pease "Chicago Made" drawing instruments, and ruling pens and bow instruments.

Wagon Loader.—George Haiss Mfg. Co., 141st St. and Rider Ave., New York. Circular devoted to description and illustration of the Haiss "Digging" wagon loader. Contains comparative costs on loading crushed stone by hand and by the loader.

Road Building Machinery.—Good Roads Machinery Co, 821 Bulletin Bldg., Philadelphia, Pa. Circular illustrating and describing the company's list of heavy road building machinery, including graders, rock crushers, road rollers, oiling machines, etc.

Rails and Track Equipment.—Sweet's Steel Co., Williamsport, Pa. 80-page catalog illustrating and describing light and heavy tee rails and accessories. Company also has issued 12-page booklet containing facts on light steel rails and process of manufacture.

Motor Trucks.—The Autocar Co., Ardmore, Pa. 16-page booklet illustrating and describing the work of the Autocar motor trucks in highway construction. Contains interesting descriptions of the methods employed on several jobs on which these trucks were used.

Tarvia.—The Barrett Co., New York. Three booklets illustrating and describing the uses of Tarvia. One shows step by step in actual photographs the construction of a Tarvia pavement; another describes how a Tarvia macadam roadway is constructed; and the third describes the uses of Tarvia in road construction and maintenance.

Scraper Conveyors.—The Jeffrey Manufacturing Co., Columbus, O. 84-page catalog devoted to Jeffrey standardized scraper conveyors. It features both single and double strand conveyors designed to handle all kinds of loose products in manufacturing and mining industries, power plants, retail coal yards, canning plants, sugar mills, and practically all other industries.

Industrial Notes

The Austin Machinery Corporation of Chicago has announced that it will rebuild its plant at Winthrop Harbor, Ill., recently destroyed by fire. The loss at this plant was extensive, but the corporation is in position to take care of all business through the duplication of its production facilities at its Muskegon plant or Toledo plant (formerly the Toledo Bridge & Crane Co.). Ample stocks are on hand at these two plants to take care of immediate demands.

Statement of the Ownership, Management, Circulation, Etc., Required by the Act of Congress of August 24, 1912,

of Engineering & Contracting, published weekly at Chicago, Ill., for April 1, 1921.

State of Illinois, County of Cook, ss.—Before me, a notary public in and for the state and county aforesaid, personally appeared Lewis S. Louer, who, having been duly sworn according to law, deposes and says that he is the vice-president of Engineering & Contracting and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor and business manager are:

Publisher—Engineering & Contracting Pub. Co., 608 S. Dearborn St., Chicago.
Editor—H. P. Gillette, 608 S. Dearborn St., Chicago.
Managing Editor—H. P. Gillette, 608 S. Dearborn St., Chicago.
Business Manager—Lewis S. Louer, 608 S. Dearborn St., Chicago.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)—H. P. Gillette, 608 S. Dearborn St., Chicago; Lewis S. Louer, 608 S. Dearborn St., Chicago; Richard E. Brown, Columbia Bank Bldg., New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) LEWIS S. LOUER.

Sworn to and subscribed before me this 23rd day of March, 1921.
(Seal) H. NELSON (formerly H. Danner).
(My commission expires December 3, 1923.)

WEEKLY NEWS SECTION

HALBERT P. GILLETTE, Chief Editor of Engineering and Contracting

(Author of the Handbook of Cost Data for Contractors and Engineers)

For fourteen years this section of *Engineering and Contracting* has been noted for the reliability, freshness and usefulness of its construction and contract news.

ENGINEERING AND CONTRACTING

is the only national weekly periodical published west of New York City that completely covers the field of civil engineering and its allied contracting.

Its subscription price as a weekly is $4.00 a year—or less than 8 cents a week. Although its contract news completely covers the whole civil engineering field every week, its articles are so edited as to cover only one of the four major branches of the field each week. For an outline of this unique plan and its advantages, read the "mast head" on the first editorial page.

Bids Asked

Roads-Streets

Ala., Birmingham—Until noon, April 15, by Board of Revenue of Jefferson for the testing and inspecting of material used on paving approximately 250,000 sq. yds. of bituminous surfacing on concrete foundation. C. J. Rogers, County Highway Engr.

Cal., Yuba City—Until April 12, by City Trustees, for improvement of portions of C St., Fairman St., Yolo St., Sutter St., Shasta St. and Teagarden Ave.

Calif., Los Angeles—Until 11 A. M., April 11th, by the Board of Supervisors of the County of Los Angeles, for the construction of a graded roadway, an oil and sand wearing surface, including grading and other incidental work on certain streets in Road Improvement District No. 179.

Calif., San Francisco—Between the hours of 2 and 3 P. M., April 13th, by the Board of Public Works of the City and County of San Francisco, second floor, City Hall, for the improvement of the easterly one-half of Tenth Ave., commencing at the southerly line of Ortega St. W. J. Fitzgerald, Secretary.

Cal., Sacramento—Until 2 p. m., April 11, by the California Highway Commission, 515 Forum Bldg., Sacramento, for an overhead crossing of the San Diego & Arizona R. R. near Jacumba, San Diego County, consisting of 3 reinforced concrete spans, each 22 ft. 6 in. long, on reinforced concrete piers and plain concrete abutments.

Conn., Hartford—Until noon, April 12th, by the Board of Water Commissioners, at office in the Municipal Bldg., for the construction of 3,100 linear feet of gravel road and two small concrete bridges. Caleb Mills Saville, Manager and Chief Engr, Pilgrad Bldg., 1206 Main St., Hartford, Conn.

Del., Wilmington—Until noon, April 12, by President of the Levy Court, Room 133, County Bldg., for the following materials: Crushed stone, gravel, slag, road tar, oils and asphalts; also for hauling from the railroad stations and distributing on the roads the stone, gravel or slag, and for hauling and applying the road tar, oils and asphalts, and spreading the stone, gravel or slag for surface treatment on macadam roads. Charles E. Grubb, County Engr.

D. C., Washington—Until 2 p. m., April [illegible] A. Wetmore, Acting Supervising Architect, Treasury Dept., Washington, D. [illegible] grading in the [illegible] Court of the Interior Dept.

Ill., Joliet—Until 2 p. m., April 11, by Phil Peck, City Clerk, for improvement of Lime St., Catalpa St., Nicholson St. and Park Ave., and for improvement of alleyways, east and west, between Joliet St and Desplaines St., and north and south, between Jefferson St. and Washington St.

Ill., Decatur—Until 1 P. M., April 13th, by the Decatur Water Supply Co., Room 209, Citizens Bank Bldg., Decatur, Ill., for the grading of road approaches to the Lost Bridge and Spangler Bridge. W. H. Collins, Consulting Engr., 223 Millikin Bldg., Decatur. (Advertisement in this issue.)

Ill., Springfield—Until 10 A. M., April 12, by the Dept. of Public Works and Buildings, Division of Highways, for 15 sections of earth grading, aggregating 62.26 miles in length and 1,025,290 cu. yds. of earth excavation; also 17 sections of bridge work, aggregating 32 bridges and 10,072 cubic yards of concrete. Clifford Older, Chief Highway Engr. (Advertisement in this issue.)

Ill., Springfield—Until 10 a. m., April 12, by Dept. of Public Works and Buildings, Div. of Highways, for the following work: Grading in Perry-Franklin Counties, 1.57 miles; Franklin County, 5.66 miles; Washington-Jefferson, 4.23 miles; Jefferson County, 4.83 miles; Edwards, 4.24 miles; Wayne County, 2.98 miles; Effingham, 4.74 miles; Knox County, 2.92 miles; Henry-Bureau Counties, 6.21 miles; Bureau County, 5.70 miles; Franklin County, 16.65 miles; Williamson County, 2.53 miles. Bridge work: Alexander-Pulaski Counties, substructures, 2 steel bridges; Ogle County, 1 concrete bridge; Perry-Franklin, 2 concrete bridges; Whiteside County, 1 concrete culvert; Franklin County, 7 concrete bridges and substructure 1 steel bridge; Jefferson County, Section 11B, 2 concrete bridges and substructure 1 steel bridge, Section 11C, superstructure 1 steel bridge, Section 12B 2 concrete bridges, Section 13B 1 concrete bridge and substructure 1 steel bridge; Effingham County, 3 concrete bridges and 1 concrete and steel bridge; Williamson County, 1 concrete bridge.

Ind., Crown Point—Until 1 P. M., April 11th, by Board of Commrs. of Lake County, at office of Geo. M. Foland, County Auditor, for asphaltic and tar products for Road Maintenance Dept.

Ind., Ft. Wayne—Until 1 P. M., April 12, by Commissioners of Allen County, at Ft. Wayne, Ind., for the construction of six stone roads in Marion, Madison, Maumee and Springfield, Cedar Creek, Perry and Pleasant Twps. Angus C. McCoy, Auditor.

Ind., Indianapolis—Until 10 a. m., April [illegible] Board of Commissioners of Marion County, Ind., for 1,000 tons, more or less, crushed stone, 1,000 ft., more or less, drain tile, 6-in. to 12-in. diameter, 1,000 ft. more or less, corrugated culvert pipe, 10-in. to 36-in. Leo K. Fesler, Auditor.

Ind., Michigan City—Until 10 A. M., April 19th, by the Board of Public Works, for the construction of two streets and one alley, said city.

Ind., Noblesville—Until 10 A. M., April 16th, by Commissioners of Hamilton County, for the construction of three roads, one in White and two in Jackson Twps. H. O. Cunningham, Auditor.

Ind., Terre Haute—Until 11 A. M., April 11th, by Commissioners of Vigo County, at Terre Haute, Ind., for the construction of three gravel roads, one in Honey Creek Twp. and two in Lost Creek Twp., to be known as the H. M. Hausman et al., Charles Milner et al., and the Scott Burgan et al. Roads. Chas. M. Lee, Auditor.

Mich., Detroit—Until 1 p. m., April 15, at office of C. W. Hubbell, 2348 Penobscot Bldg., Detroit, for the furnishing of all materials and constructing asphalt on concrete pavement consisting of approximately 11,200 sq. yds., together with the necessary curb, inlets, catchbasins, mud gates and connections.

Mich., Grand Rapids—Until 1:30 P. M., April 19th, by Board of County Road Commrs., of Kent County, County Bldg., for improvements of 4.592 miles of road.

Mich., Highland Park—Until 8 P. M., April 11th, by Delmer C. Gowing, City Clerk, 20 Gerald Ave., for furnishing materials for street work.

Mich., Hillsdale—Until 2 P. M., April 15, by Board of County Road Commrs., of Hillsdale County, for constructing 11.424 miles in Hillsdale and Calhoun Counties.

Mich., Houghton—Until 10:30 A. M., April 19th, by Board of County Road Commissioners of Houghton County, at Court House, for construction of 6.516 miles of road in Houghton County.

Mich., Kalamazoo—Until 2:30 P. M., April 18th, by State Highway Dept., 221 Pratt Bldg., Kalamazoo, for improving 2.841 miles in Casco Twp., Allegan County.

Mich., Paw Paw—Until 1:30 P. M., April 15th, by Board of County Road Commrs., of Van Buren County, at Court House, for improving 5.231 miles of road in Antwerp and Paw Paw Twps., Van Buren County.

Mich., Sault Ste. Marie—Until 1:30 P. M., April 18th, by Board of County Road Commissioners of Chippewa County, at Court House, for improving 4.006 miles of road in Rudyard Twp.

Minn., Ortonville—Until 10 A. M., April 12th, by A. V. Randall, County Auditor, Big Stone County, for the construction of 1.56 miles on State Road No. 4, 2.26 miles on State Road No. 6, 9.3 miles on State Road No. 6, and 2.6 miles on State Road No. 1.

Mo., St. Joseph—Until April 18, by the State Highway Dept. in St. Joseph, for grading and bridging 5 miles of road in

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

Published by Engineering & Contracting Publishing Co., 608 South Dearborn St., Chicago.

HALBERT P. GILLETTE, *President and Editor* LEWIS S. LOUER, *Vice-President and General Manager*
New York Office: Rm. 403 Columbia Bank Bldg., 507 Fifth Ave., RICHARD E. BROWN, *Eastern Manager*
Cleveland Office: Room 413 Engineers' Bldg., LEO EHLBERT, *Manager*

The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Immorality Among State Legislators

It is commonly regarded as immoral to counsel any one to disregard the law. Eugene Debs is serving a prison term for that sort of immorality. Yet in the city of Chicago many men (some of whom are lawyers) are advising tenants of buildings to ignore the contracts with their landlords, and to retain possession of their apartments after the expiration of their leases. Even more deplorable are the bills before the Illinois legislature by which it is sought to circumvent the constitutionally guaranteed rights of property owners. For example, one bill provides for the placing of all dispossession suits at the end of the court calendar, so that landlords will be unable to secure a trial within a year or two. Another bill proposes to fix a merely nominal penalty for unlawfully holding possession of an apartment. It may well be doubted whether the Supreme Court would sustain any law that aims at circumvention of constitutional rights, even where the circumvention is merely temporary. But we are less concerned with the constitutionality of such laws than with the moral state of mind that they disclose.

The other day the lower house of the Wisconsin legislature almost gave a majority vote in favor of a resolution advocating the repudiation of the national war debt! Nor have we seen a single editorial comment upon this astonishing exhibition of immorality.

On a parity with such action we may cite an ordinance recently passed in Los Angeles, restricting gross rental charges to 11 per cent on the cost of the real estate. This ordinance was passed by the City Council in the face of advice by the City Attorney that it was unconstitutional. But what does the basic law of America—the Federal Constitution—amount to in the eyes of the Los Angeles City Council, if it is esteemed popular to secure lower rents by any expedient, whether foul or fair?

One of our readers, an eminent engineer, writes:

> I have recently read Prof. Soddy's inspiring volume on "Science and Life," and I am convinced that the complaint from which the world is suffering today is moral bankruptcy. I believe that engineers even more than preachers must bring about the world's moral restoration.

In this connection we may suggest that ethics and economics are twin sciences, if indeed they are not parts of one science. If so, there is nothing incongruous in an engineering preacher or a preaching engineer. May it not be feasible to demonstrate by statistics that general honesty and general prosperity have always been functions of one another, however often individual exceptions to the rule may be found?

Approaching the Unattainable

Now that so much is being written about Einstein's discovery that Newton's law of gravitation is only approximate, it may be of interest to read what Prof. Jevons wrote nearly 50 years ago in his "Principles of Science":

> The law of gravitation is expressed in the form of $F = \frac{Mm}{D^2}$, meaning that gravity is proportional directly to the product of the gravitating masses, and indirectly (inversely) to the square of their distance. * * * Philosophers have by no means always supposed that the law of gravity was exactly true. Newton, though he had the highest confidence in its truth admitted that there were motions in the planetary system which he could not reconcile with the law. Euler and Clairaut who were, with D'Alembert, the first to apply the full powers of mathematical analysis to the theory of gravitation as explaining the perturbations of the planets, did not treat the law as sufficiently established to attribute all discrepancies to the errors of calculation and observation. In short, they did not feel certain that the force of gravity exactly obeyed the well known rule. The law might have involved other powers of distance. It might have been expressed, for example, in the form
>
> $$F = \frac{a}{D} + \frac{b}{D^2} + \frac{c}{D^3}.$$
>
> and the coefficients a and c might have been so small that those terms would only become apparent in very accurate comparisons with fact.

Jevons states that it will always be impossible to prove that any quantitative law is precisely correct because the proof must ultimately depend upon the agreement of the law with physical measurements, and measurements can never be precise. He says:

> When we examine the history of scientific problems we find that one man of one generation is usually able to make but a single step at a time. A problem is always solved for the first time by making some bold hypothetical simplification upon which the next investigator makes hypothetical modifications approaching more nearly to the truth. Errors are successively pointed out in previous solutions, until at last there might seem little more to be desired. Careful examination, however, will show that an indefinite series of minor inaccuracies remain to be corrected and explained, were our powers of reason sufficiently great, and the purpose adequate in importance.

In other words, no quantitative physical law is more than an approximation to the full truth. Hence the full truth will never be known to man. This is a startling generalization, but it appears to be irrefutable. Strangely enough, Jevons, after making such a generalization, undertakes to show that Newton's law of gravitation is "probably complete and true." But now comes Einstein, who proves it to be only an approximation to the truth. Who will come next and show that Einstein's "perfect law of gravitation" is itself but an approximation and therefore imperfect?

Design of Sewage Digesting Tank

To the Editor: I offer the following design for a sewage digesting tank as a subject for constructive criticism:

Any one having had experience in modern methods of sewage treatment cannot fail to be impressed with the obvious fact that our present methods are crude and inefficient. Probably the ideal method will not be devised for many years to come. Yet from the present state of knowledge acquired by the study and experiments of a large number of men of high scientific attainment, it seems possible to devise means somewhat less crude and more efficient than any now in use.

It is not believed that the sketch represents the last word possible in digesting tanks but it does seem to be a step forward. At first glance it may seem too complicated, but when the advantages of comparative shallow depth are considered, if the extra partitions will accomplish the results for which they are designed, they are well worth constructing.

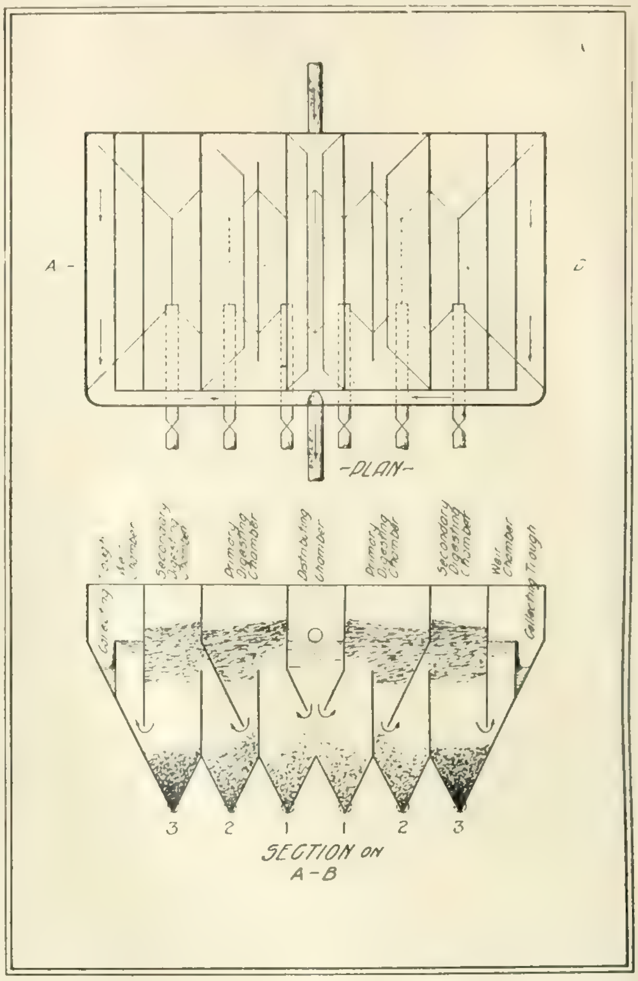
To illustrate the operation of the tank: Assume an inflow properly distributed over the surface of distributing chamber. As it settles through the slot sufficient velocity will be maintained to prevent the return of any solids. Those settling to the bottom will be delivered by the central wedge to the side of the settling basin, causing previous deposits to work over to the other side, and thus be free to rise when fermentation begins without being held down by later deposits. On rising they will follow the vertical partition, joining the flow of sewage having at the top of the baffle a velocity sufficient to insure being carried to the surface at the side of the digestion chamber. This will cause scum to rotate to the other side and thus be ready to descend at the proper time without being impeded by later deposits. In falling to the second settling basin and again rising for the second period of activity, the process is repeated and the finished sludge is collected in settling basin No. 3, from which it may be drawn to drying beds as occasion may require. Pipes with gates are provided for each settling basin to provide means of cleaning each of such deposits as might chance to collect and fail to take the usual course.

Separated from the second scum chamber by a baffle is the weir chamber designed to remove the clarified water by a thin stream over weirs extending the entire length of each side. All sides and baffles where not vertical will be constructed on an angle not exceeding 30° from the vertical,, as it is found that at 45° slope the solids will collect and be retained on the surfaces, and an attempt to draw sludge often results in formation of a clear cone, leaving sludge hung up on the sides undisturbed.

In taking care of Imhoff tanks it has been found necessary to install a pump, taking water from weir chamber and discharging a stream from a fire hose onto the surface of mat to keep it in a working fluid condition as well as to separate the finished sludge from later accretions. This also probably assists digestion and reduces the supply of odorous gases by increasing the supply of oxygen.

A similar arrangement for this tank will be desirable not only as a means of treating the scum, say, for a half hour twice a day, but for breaking up any "sets" that may be discovered when cleaning tanks.

It will be observed that the passage of sewage through the tank is so arranged that it passes through the mats with a very gentle flow, while at points where designed to assist in moving solids to their proper places, there is always an accelerated current. Also whenever solids are to be moved it is intended that the progress be continuous and in no place be impeded by later accretions.



Plan and Section of Sewage Digesting Tank.

This is submitted with the hope that discussion by experts may result in devising something that is a little better than anything now used.

EDWIN P. DEWEY,
City Engineer.

Pasadena, Calif.

Weir Formulas on Simplified Assumptions

To the Editor: The writer was very much interested in the article "Weir Formulas on Simplified Assumptions," by Milton F. Stein, published in Engineering and Contracting, Feb. 9, 1921. It is certainly true, as Mr. Stein states, that often the general acceptance of certain engineering formulas leads to a cessation of analytical investigations and consequently of true scientific progress.

There are two points, however, in which the writer disagrees with the statements or assumptions of the author. He states, "That it (his formula) gives a discharge slightly below the actual is probably due to the assumption of a uniform velocity throughout, whereas the velocity increases somewhat from the surface downward." Without going into a mathematical discussion of the matter the writer wishes to call attention to the fact that any departure from uniform velocity over the area of flow will give a greater velocity head than will a uniform velocity for the same flow and cross-section. Since the relation of Y to $\frac{A}{b}$ is not changed by this condition it can be readily seen that if the velocity is not uniform the constant in Equation II, $Q = 3.08 \sqrt{\frac{A}{b}}$ in Mr. Stein's article should be less than 3.08 instead of greater.

Now since Mr. Stein has not introduced any coefficients to take care of roughness, but has derived his formula on the basis of no friction, internal or external, and still obtains a theoretical result that is less than atcual tests show is obtained, it is plainly evident that there is an error in the assumptions. The writer has thought about this matter for some time, and now believes he has a satisfactory explanation.

The author has assumed that the entire loss in static head in discharging water over the weir is the drop in surface elevation, namely: the value Y. This would be true if it were a submerged weir having a downstream height above the weir equal to $h - y$. Since the weir is not submerged, however, there is no back pressure on the stream of water passing the weir and consequently the static head is somewhere between y and h, probably somewhat close to $Y + \frac{h - y}{2}$. Using this quantity as the static head will give a coefficient for Equation II enough in excess of 3.08 so that by taking into account the velocity head due to non-uniform flow and internal and external friction, the formula will not be far from the empirical Francis formula $Q = 3.33\ b\ h^{3/2}$.

A. G. HUSTED.
Assistant Engineer, Department of Public Service.
Cleveland, O.

[In accordance with our custom, the above letter was submitted to Mr. Stein. His reply follows.—Editor, Engineering and Contracting.]

To the Editor: Mr. Husted's discussion was read with much appreciation. My short article on weir formulas was in a sense the by-product of another hydraulic investigation, and therefore more in the nature of a memorandum, rather than an analytical investigation. As I mentioned, perhaps with insufficient emphasis, the principal interest lies in the fact that with no assumptions except that, given a notch in the side of a reservoir, conditions will so adjust themselves as to cause the maximum possible flow through same, a formula can be derived giving the flow, which approaches quite closely to experimental results; whereas the conventional formula, based on a number of arbitrary assumptions requires the use of a coefficient to make it agree with actual conditions. I do not present my formula as a finished product, but because it illustrates the fact that agreement between results obtained by analytical methods and by experiment does not necessarily prove the validity of the method of analysis, or of the assumptions on which it is based Whoever has computed the flow over weirs of unusual form by the conventional method, or has attempted to deal with the transitional stage between weirs and orifices, and has later had opportunity to check his computations experimentally, knows the difficulties of reconciliation, and has trouble in holding the time-honored weir formula in proper veneration. Personally, I think that the laws of flow for weirs, orifices and short channels, and their interrelation offer a profitable field for analytical investigation.

I do not agree with Mr. Husted that there is any considerable external friction in a sharp-crested weir, and there is certainly no evidence to the eye of internal friction in the smooth-flowing water passing over the weir, at least until it passes the crest, after which it is "water over the dam" for purposes of our discussion. It is otherwise in the case of orifices, where the friction of the sides retards some of the water filaments, and influences the coefficient slightly The use of the coefficient for orifices is justified on theoretical grounds, to rectify the filaments approaching the orifice radially, and is not inserted merely to reconcile theory and practice, as is often supposed.

MILTON F. STEIN.
Chicago, Ill.

Prevention of Foaming in Gas Chambers of Imhoff Tanks.—In connection with his paper presented Feb. 18 before the New Jersey Sewerage Works Association, Mr. John R. Downes, Superintendent of the joint sewerage disposal plant for Plainfield, North Plainfield and Dunellen, N. J., remarked that practically every known method has been tried to prevent foaming in the gas chambers of the Imhoff tanks. These methods included: Seeding with foreign sludge; application of lime to the sewage in the gas vents; application of water under pressure to scum formation; application of steam; breaking of scum with paddles; covering gas vents so as to retard the drying of the scum; and the reversal of the direction of flow in the tanks. It is Mr. Downes' opinion that in order to prevent the foaming of the scum over the top of the tanks, it is necessary for him to operate his tanks in rotation and to pump out the upper portions of the digestion compartments of the tanks at least once a year.

Residual Alumni in Filtered Water

Amongst water works sanitarians at the present time, no subject is attracting more attention than the question of residual alumina in mechanically filtered water. The American Water Works Association consider it so important that a special session is to be devoted to it at the forthcoming Cleveland meeting, when experts frcm all over the continent are expected to take part in the discussion.

Prior to the meeting of the New England Water Works Association in Albany in October, 1919, when the discussion on the Toronto drifting-sand filters took place, and up to the time of the publication in The Canadian Engineer of a valuable contribution on the subject by Messrs. Howard and Hannon, of the Toronto Filtration Laboratories, the subject had received little attention, it being generally thought that in all efficiently operated mechanical filtration systems where a coagulant was used, the effluent was free of alumina in any shape or form. Since the publication of the above-mentioned article the subject has been investigated in many plants in the United States and Canada, and in most instances traces of alumina have been found in the filtered water.

There would seem to be three conditions in which alumina can play an important part in public water supplies: (1) Its passage through filters in undecomposed or active form; (2) its passage through filters in decomposed form, in the nature of alumina hydrate, with subsequent precipitation in the water mains; and (3) its passage through filters in the form of decomposed residual alumina so finely divided that it does not precipitate, but remains in almost invisible suspension in colloidal form.

The first condition is generally caused by an excess of alumina being added to a water which does not possess sufficient normal calcium alkalinity to decompose it. The second condition is the result of insufficient sedimentation or inefficient filtration; and the third is a natural condition occurring in almost all waters after filtration, the hydrate passing through in colloidal form and subsequently becoming an aluminate. The last condition would seem to exist in the effluents of many plants without the fact being generally recognized.

Recent developments have shown, however, that coagulation is not always controlled by the chemical composition of the water. There are several cities where an excess of alkalinity exists but where flocculation is incomplete or is held up for some apparently unexplainable reason. Expert chemists and bacteriologists state that the explanation of this is controlled by conditions frequently encountered in colloidal chemistry, involving a study of the causes of precipitation and also of the hydrogen ion concentration of the water under treatment. It was recently announced that it had been found in the laboratory of the Toronto filtration plant that by altering the hydrogen ion concentration by titration and filtration, the residual alumina could be made to disappear. Although this is of considerable importance and great scientific interest, it is of little value from a practical water works point of view, because the lowering of the titratable acidity, which would increase the hydrogen ion concentration and consequently mask the alumina, might cause the water to become highly corrosive in nature.

The purification of water by artificial means furnishes an excellent example of the application of colloidal chemistry to industry. At present there is no more complex study than that of colloidal chemistry, and this modern field of scientific research is expected to furnish the true solution to many waterworks problems which are now more or less shrouded with mystery.—Editorial in The Canadian Engineer.

The Limits of Tidal Power

We must be careful not to get an exaggerated impression of the available tidal power, even when the whole supply in any given district is rendered mechanically available. This is shown in a recent study by Norman Davey, published in The Engineer, in which the writer makes a comprehensive survey of the available tidal power as shown by the tide tables of the British Isles. We learn that at the extremity of Cornwall the mean range is about 12 ft. and that as we go northward upon the west coast, it increases until a maximum mean range of 31 ft. is reached at Portished, from which point the value decreases until it drops to 12 ft. at the Mull of Galloway. Around the rest of the west coast of Scotland it rises to between 7 and 10 ft. On the east coast of Scotland the value is still low, the average being about 11 ft. It is 16 ft. in the River Humber, and at the London docks the mean tidal range is 17¼ ft.

Considering the use of bays and estuaries for the development of tidal power, particular note must be taken of the difference in the area of the surface of the water at high and low tide. Thus, the estuary of the Salcombe River in Devonshire shows a high spring tide surface area of 2.4 square miles, and a low spring tide area of only .58 square miles, and this variation is found, to greater or less degree, at all the sites. In his study of the total tidal capacity of the United Kingdom, the choice was limited by the conditions of, first, a mean tidal range of not less than 15 ft.; second, a total output reduced to continuous work of not less than 10,000 HP.; third, the avoiding of building dams outside of large seaports; and, lastly, the necessity for keeping the length of the dam within reasonable limits. In all the stations thus selected, the half-tide system working at a constant head for three hours in every twelve was adopted, and power factor is the value of the total power output reduced to a continuous average throughout both the monthly and daily cycles.

Within these limitations it was found that 21 bays and estuaries were available, ranging from a maximum at the mouth of the Severn, with a total average horsepower, reduced to a continuous basis, of 437,000, to a minimum at Fleetwood where it is estimated that the total average horsepower works out at 18,300. The grand total of horsepower thus available, in intermittent power, but expressed as an average continuous power factor, gives a grand total of 2,263,000 HP.

A survey of the tidal power possibilities of the world shows that there are not many localities in which the tidal range is sufficient for profitable power development.—Editorial in the Scientific American.

Drainage as a Malaria Control Measure

Drainage as applied to malaria control is quite different from the usual drainage for agricultural purposes. Lands drained for the latter purpose frequently produce mosquito breeding places. In the Proceedings of the Florida Engineering Society is contained an article by A. Bresth, in which are outlined some of the effective measures to be observed in malaria control drainage. The following notes are taken from the article.

For mosquito eradication, not only must the land be properly drained, but the drainage ditches must be so planned, constructed and cared for that they will not become a source or propagating place for mosquitoes.

As a general rule shallow water is more favorable to mosquito production than deep water. A depth of an inch is sufficient; therefore in order to prevent mosquito breeding we must remove all the water or make conditions unfavorable.

The mistake is frequently made of constructing ditches chiefly for disposing of storm water or "flood water," no provision being made for subsequent conditions when the normal water line is reached, which condition may favor mosquito propagation.

Many persons think that mosquitoes come from stagnant water only, but as a matter of fact mosquito larvae are often found in large numbers in streams having a fairly good current. Of course, along the shallow banks of streams, and irregularities in the path of streams where eddies may form, the velocity is markedly decreased. In most streams many places occur where the water is almost, if not absolutely, without current. It is in these places that mosquito propagation is found to occur.

A stream should be made to have steep banks directly above and below the flow line, uniform grade and width, and a straight course, and be free from grass, sticks, stones, or other obstructions that would interfere with the current. These conditions are seldom found in nature, but the nearer a stream approaches them the less mosquito breeding will be found.

There are two principles to be observed in the construction of ditches or drains for anti-mosquito work:

They should have clean cut, sloping edges, narrow bottoms, and straight courses, if possible. In average soils the slopes of the sides of ditches should be about 45°. In sand and mud the slope is flatter, while in hard clay and soft rock it may be almost vertical. The lining of ditches may be employed in cases where maintenance of open ditches is expensive. Lined ditches are more permanent, easily cleaned, require less inspection, and are ultimately less costly.

Sub-surface drainage, in connection with mosquito control, is used for two purposes:

(a) To lower the water table or ground water so that pools of surface water will be absorbed more rapidly by the soil.

(b) To intercept seepage planes and prevent seepage water from hillsides reaching and collecting on the surface of the ground.

The advantage of sub-surface drain, as compared to the open ditches, is that it is self-cleaning, maintains itself, permits of rapid inspection, needs very little attention, requires no oiling, and permits no exposure of water accessible to mosquitoes.

Whenever the topography of an area is such that there are a number of isolated low spots which have no surface outlet, the ordinary methods of drainage cannot be applied. In a geological formation such as in Florida, where large fissures, and caverns in the limestone underlie the loam, clay or sand which forms the surface mantle, it is possible to resort to what is termed vertical drainage. This is accomplished by sinking artificial shafts or wells into the ground until this porous strata is reached. Quite frequently we find these vertical shafts in nature and they are commonly designated as sink holes. This method is very successful where provision is made to prevent the vertical channel from being clogged by silt, sand, and debris. In every case a sanitary survey of the drainage area should be made to see if any of this drainage comes from polluted sources and if the city supply or local water supply is obtained from the same strata into which the drainage well is discharging.

Collections of water that cannot be economically drained should be filled when practicable. In making fills with earth or clay, care is taken not to leave depressions on the surface of the fill that may hold water, and the bottom of the "borrow pits" should be made self draining. Porous material, such as cinders, is very good for filling ground. In the vicinity of lumber mills, waste, sawdust and shavings, are available in quantity, and when used for filling should extend several inches above the surface of the ground to allow for shrinkage.

Oiling of water surfaces as an anti-malaria measure should be supplementary to proper drainage. When funds are not available for drainage mosquito propagation can be largely controlled by oiling.

The object to be attained in using petroleum or other oils is to destroy larvae of mosquitoes. To attain this the surface of the water must be completely and continuously covered with a film of oil.

The effects thus produced in preventing mosquito breeding are:

1. Where mosquito larvae are present, such larvae can not penetrate the oil film with their breathing tubes and so drown and die.

2 Mosquitoes do not lay eggs on the oiled surface of water.

There are many grades of oil on the market that will serve for mosquito destruction, ranging from the very light oils, such as kerosene to the heavier oils, known as crude oil. The disadvantages of using oil are rapid evaporation, high cost, and possible waste due to the invisible oil film formed. It has three advantages. It forms a thin film; it spreads rapidly and it is readily obtained in small or large quantities.

When drainage is impossible, and oiling is ineffective or costly, the number of mosquitoes may be kept down by introducing fish into the pools, streams and ditches. In Florida, a top minnow, Gambusia Affinis, is very effective in the control of mosquitoes.

Results of Run-off Experiments With Muck Soil

Experiments having for their object the determination of a reliable, reasonable, economical run-off for providing that degree of drainage considered advisable for the Everglades of Florida, conducted by the Everglades Drainage District, were described by Mr. F. C. Elliott in a paper presented at the last annual meeting of the Florida Engineering Society. An abstract of the paper follows:

Principal Factors Investigated.—In arriving at final results the following principal factors entering into the problem were investigated:

1. Storage.—Determining the storage or absorption value of muck soil under actual field conditions.
2. Evaporation.—Determining the amount of evaporation from such soil including transpiration of water from vegetation growing upon it.
3. Water Table.—Determining the most advantageous water table for the growing of crops, combined with a high degree of flood protection.
4. Subsidence.—Determining soil subsidence, the effect of the water table and land tillage upon the same, and the degree to which subsidence should be compensated for in ditch construction.

Each of the subjects above named have a direct and important bearing upon drainage and ditch design. Of the above, 1 and 2 have been determined within reasonably close limits; 3 and 4 show decided general tendencies, but experiments and observations thus far have not given results reducible to figures, nor can they be set down within closely defined limits.

Apparatus Used in the Experiment.—The apparatus for conducting these experiments consists of a sheet iron box 2 ft. square and 4 ft. deep, the seams being riveted and soldered to secure perfect water tightness. To the outside of the box is attached a water gage glass extending vertically from top to bottom and connected with the box by a valve at the bottom and a pipe nipple at the top. The glass has a gage divided into inches reading zero at the top and graduated downward corresponding to depths below the surface of the soil. The box rests near the ground and is enclosed and protected by a lattice against the rays of the sun. A section of muck soil in its natural condition was placed in the box, filling it level full. Some suitable vegetable growth, in this instance Augustine grass and Bermuda grass, was planted and water added to the box to bring the water table to a convenient starting point. In conjunction with the soil box a rain gage is observed. Soil water levels are recorded from test holes in the natural muck soil at the station. Water evaporation pans are also kept for comparison of evaporation between water surface and losses from evaporation and transpiration from the soil box.

How the Experiments Were Conducted.—The experiments were co-ordinated as nearly as practicable with actual field conditions as observed.

The operation of the box is as follows: The water gage is read and tabulated as inches depth from the surface of the soil, records being taken each morning and after such rains as require additional measurements. Observance is made upon the growing vegetation. The rain gage is read and recorded. The level of water in the test hole is recorded.

The philosophy of the foregoing is as follows:

Water can enter the box only through rainfall. This is measured by means of the rain gage. Water can escape from the box only by (a) evaporation, which is measured, and (b) drawing off water through the valve at the bottom of the box, which represents drainage.

Under the term "evaporation" is included all the loss of water by evaporation direct from the soil and transpiration through the vegetal cover.

The effect of evaporation upon the soil is disclosed by the lowering of the water table and of course rainfall produces a rise in the water table. The rain gage measures the amount of rain, and the water glass on the soil box shows the rise in the water table due to that rain. By numerous repetitions there is disclosed a ratio between rainfall and rise of water table, and likewise a ratio between evaporation and the lowering of the water table. The following for instance would be an observation of a hypothetical case: On the morning of a given date the soil box gage shows 32 in., which is a water table reading. During the day a rain of .6 in. is recorded. On the next morning the gage shows 29 in. Ignoring evaporation for the moment it appears that 3 in. of soil were required to store or absorb .6 in. of rain.

To determine the evaporation which took place from the soil daily and for the month, the rainfall is gaged for the month and at the end of the period water is either added to or drawn from the box to restore the water table to the same level as at the beginning of the month. In addition to the amount of water added or drawn off, allowance is made for rainfall. Whereupon the water which entered the box, having been measured, is a known quantity, the amount drawn off as drainage, if any, being measured is a known quantity, it follows that the quantity not otherwise accounted for represents evaporation. Through the conduct of the experiments the storage value of the soil is also ascertained. After the experiments progressed for several months and reliable factors were obtained for reducing the amount of evaporation from soil readings to actual depths and vice versa, the boxes were permitted to operate as nearly as possible under conditions imposed by nature and their behavior thereunder was observed and recorded. This brief reference to the use of the experimental apparatus will suffice to afford information by which the accompanying diagram may be analyzed.

What the Drainage Experiment Diagram Shows.—Referring to the diagram the following conventions are used:

Inches of depth are plotted as ordinates.

Time elements are plotted as abscissas.

The shaded horizontal line represents ground surface.

The line 4 represents rainfall in inches, that part below the surface line representing the trace of the water table beginning at 50 in. below ground. This line represents a water movement with no loss from any source. It is purely a hypothetical line plotted for the purpose of aiding in graphically developing other lines, which are in part resultants of the rainfall curve.

The diagonal lines 5 represent evaporation curves for their respective months.

The broken line 6 is a resultant of rainfall and evaporation. This line shows what would have occurred in the soil with an initial soil water level at 50 in., under the prevailing rainfall and evaporation conditions, but with no drainage taking place.

The broken line 7 represents combined rainfall as it prevailed and drainage as expressed by the factors in the following table for varying depths:

ASSUMPTION FOR DRAINAGE.

Water level below bank. In	Cu. ft. per second per square mile.	Depth inches per 24 hours. Neat inches.	Soil equiv.
12	21.2	.80	4.0
18	17.8	.67	3.4
24	14.5	.54	2.7
30	11.5	.43	2.2
36	8.5	.32	1.6
42	6.0	.23	1.2
48	4.2	.16	.80
50	3.8	.14	.70

The solid shaded line 8 represents the resultant of three forces, rainfall, evaporation, and drainage, each acting in manner and degree as shown by their respective curves under the conditions prevailing. The factor used in conversion of neat measurements, of rainfall, evaporation and drainage to sub-surface equivalents, is the ratio 1 to 5. This expression represents the water movements in the soil resulting from rainfall or evaporation measured directly in inches. This ratio was developed from soil experiments, and indicates that in a fairly compact muck soil after drainage, cultivation and cropping for three or four years, each inch of rainfall, drainage or evaporation will affect the water table five fold. As above stated therefore, readings below surface are expanded five times from actual readings in inches expressing neat quantities. The ratio of 1 to 5 is subject to a variation of 5 per cent in either direction.

Field observations indicate that a depth to water table of 50 in. is favorable to drainage, and to agriculture. A base line 50 in. below the surface line is therefore used, from which to plot vertical measurements.

The diagram relates its own story. The line 4 shows that during July, August, September and October, there were 29.82 in. rainfall. The peak period was from Sept. 15 to Oct. 5, during which 20 days 13.17 in. of rain fell. The line 6 representing the resultant of rainfall and evaporation, shows that 96 days were required to bring the water to the surface under a rainfall of 23.8 in. The total amount lost by evaporation and transpiration for the four months' period was 16.52 in. The remainder of the rainfall, 13.30 in., was the amount necessary to be removed by drainage in reducing the ground water level to the original depth. Taking the period from Sept. 15 to Oct. 5, of the 13.17 in. of precipitation, air losses represent 2.65 in., or slightly more than .13 in. per day. The chief value of evaporation, therefore, appears to be not the particular amount of water which will be removed from the soil during the actual time of the flood, but rather its cumulative effect in preparing the soil for the reception of water before the flood comes, and after it passes; in other words its augmenting effect on soil storage. The broken line 7 representing the resultant of rainfall and drainage, shows that drainage in amounts indicated by the table, but with no allowance for evaporation, would have kept the water entirely below ground, the level reaching the maximum of 15 in. on Oct. 5, after which it went down.

The shaded line 8 representing the resultant of evaporation, drainage, and rainfall, under the conditions imposed during the months, July, August, September and October of 1920, brings out the value of evaporation in conjunction with soil storage and drainage for affording increased flood protection.

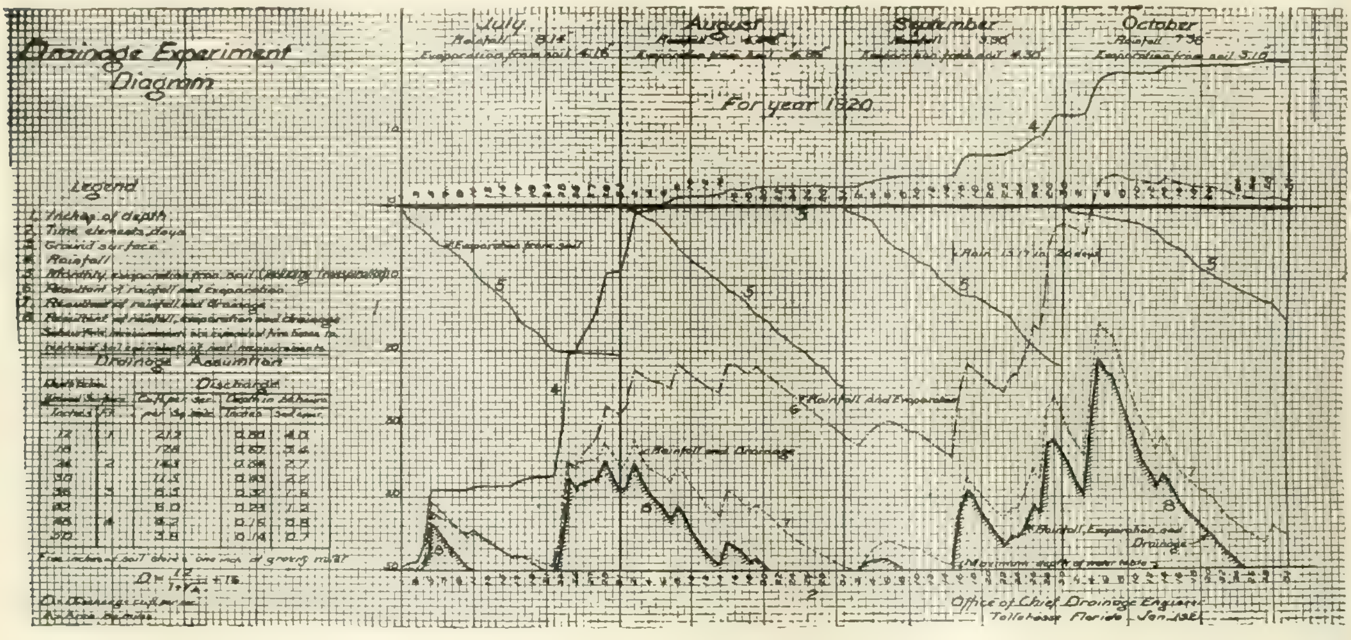


Diagram Showing Results of Drainage Experiment of Everglades Drainage District, Florida.

It may here be stated that only the above four months have been used because they represent the heavy rainfall period producing most nearly flood conditions. Furthermore, for the past six years, during which these experiments have been conducted representing upwards of 11,000 recorded observations, this was the first season of a nature to afford the information desired, it being the only one which has nearly enough approached the severe flood condition, and as the determination of drainage load rests with ascertaining the maximum load, the ordinary or average run offs is of little or no consequence in designing a drainage sytem. We are interested here with the peak load, and though the past season can not be said to have afforded rainfall sufficient to produce a maximum flood, yet it was an unusually severe season, being by far the heaviest since 1912, and the data taken can be relied upon under the conditions imposed. Furthermore, knowing the intensity of the rain storms during the past rainy season, and the intensity of storms of other rainy seasons, opportunity is afforded to determine by comparison the needs as dictated by other storm periods, and thereby to forecast probable future requirements. Again it is not intended to provide a runoff capacity sufficient to prevent overflow under the maximum flood condition, which is likely ever to occur in the Everglades. The intention is to provide as much safety against overflow as agricultural needs require under an economical and practical plan of drainage. To provide such an adequate and elaborate drainage system as would take care of the severest storms ever likely to occur, would mean an expenditure far beyond the ability of the drainage district in its early stages to bear. The degree of drainage, therefore, is largely a question of dollars and cents, the general proposition being to afford the maximum flood protection consistent with cost of such system, and the ability of the district to bear the cost burden. As the district develops and becomes financially able to incur larger expenses the drainage system may be enlarged if advisable by way of improvement rather than as an initial necessity.

Storage Capacity of Muck Soil.—An important disclosure shown by the experiments is that muck soil has a very important and valuable storage capacity when the water table is at a favorable level. The records of the soil boxes showed in the beginning on virgin muck soil that each 3 in. of soil above water level was capable of storing 1 in. of rain. Later after the soil became more compact by tillage and drainage, the storage factor was reduced to 1 to 4, and finally to the ratio of 1 to 5, which latter has been maintained for the past three years. It is probable that further reduction of storage value would take place in time, and conservative drainage design would require taking this probability into consideration. The factor of 1 to 5 is here used for the reason that the intention was to set down the observed results from actual cases. Later on a hypothetical case will be suggested, which would appear to be warranted by the data at hand.

On the assumption of water table at 50 in. as the working level to start with, and the soil in fair tillage condition, the same is capable of temoprarily storing 10 in. of rain to the saturation point. The amount capable of being temporarily held between the saturation point and the drained point by no means represents the total amount of water in the soil. This is simply the difference between the saturated condition and the drained condition. It is the gravity water of the soil. There further remains in the soil a large relative amount of water which is not susceptible of abstraction through drainage, but which is readily available in greater part for plant growth and for evaporation. This is capillary water. There still remains a small residue of moisture as hygroscopic water, not susceptible of removal by natural processes, of no import as far as drainage is concerned. Water of capillarity, though of first importance for agricultural purposes, is of secondary importance in so far as drainage is concerned. Even though the capillary water content is reduced during the spring before the rainy season comes on, the first heavy rains will restore this part of the soil water, and thereafter the absorptive power of the soil is confined to gravity water only. The value of capillary action lies in its assistance in reducing the water table by its draft upon the same for supplying evaporation and transpiration needs. It does not necessitate intricate analysis to show that this storage coupled with other favorable hydrological conditions in muck soil is of great value from a drainage and flood protection standpoint. An examination of the diagram on which are graphically shown the records from the cases under observation, suggest certain things as corollary to the principal proposition, some of which may be stated as follows:

1. The storage capacity of muck soil is a valuable drainage factor.
2. The value of this storage varies directly as the depth of soil above the water table.
3. The storage capacity of the soil under favorable water table conditions will permit taking advantage of evaporation to assist drainage.
4. That in designing a drainage system for muck land, account may be taken of the storage value of the soil, provided ditches of relatively deep section are used and at sufficiently close intervals to secure a good depth of water table and for restoring and preserving the storage value of the soil. This operation will approach in its nature sub-surface drainage.
5. That soil storage tends to equalize run-off and the effect of the same will extend to the main canal system as well as to the lateral system.
6. That deep soil above water table is a tremendous protection against flood.

It may be interesting to know, in connection with the experiments, that in a certain section of the Everglades immediately south of Lake Okeechobee where the main canals had been provided, but where no laterals had been dug the water table in July, 1920, was at practically 4 ft., and that under the rainfall conditions which prevailed, and as shown by the diagram, combined with the condition due to complete absence of lateral ditches, and therefore the absence of drainage, except an entirely negligible amount due to deep seepage, there occurred precisely the thing shown on the diagram by the evaporation line. That is to say, the rain which fell and which soaked into the ground, having no way of escape, gradually accumulated through successive rains, finally reaching the saturation point, and thereafter the surplus water which could not soak in and did not evaporate, stood upon the ground. The date on which water first appeared on the surface in the field was two days later than the date developed from plotting the records on the diagram taken from the soil box experiments. In other words the behavior of the soil boxes was the same as the behavior in the field, and to that extent results with the soil boxes are supported by the concordant behavior in the field under the similar conditions prevailing.

Effect of Soil Subsidence on Drainage Water.—Over selected areas in the Everglades, level lines have been run from time to time to determine the amount of soil settlement. During the past six years subsidence has taken place generally over the upper Everglades on the land drained or partly drained and varying in amount from 2 to 3½ ft. according to depth of soil, character of the muck, extent of cultivation, and depth of normal water table.

Shrinkage of soil takes place through three dimensions, but the resultant of all three is inevitably downward. The resulting subsidence diminishes ditch capacity principally in two ways. First, and most important, by the material reduction in ditch section through diminished depth of ditch. Second, by reducing the slope or grade of the ditch. In the first case we will suppose that since the original cutting of the ditch 5 ft. deep, a soil subsidence of 2 ft. has taken place. The result of this subsidence is literally that there remains a ditch 3 ft. deep, which originally had a depth of 5 ft. This is no more and no less than the actual result for the reason that subsidence, in so far as we have been able to observe, takes place from the surface downward, and is confined almost entirely to the zone above water level. No discussion is needed to disclose the serious nature of this action upon a drainage system constructed without ample provision to compensate for this loss by soil subsidence.

In the second case the degree of effect upon the drainage works and its import depends upon whether or not the areas are those of flat low sections which can ill afford to lose even this small elevation, and which will thereby suffer by reduced velocities of flow from the flattened grades. With reference to subsidence, the ultimate extent to which this may take place on muck soil has not yet been determined for the Everglades. It appears to depend largely upon depth of the muck soil at least up to 12 or 14 ft. In sections where soil was 10 to 12 ft. deep, which has been drained or partly so, there shows for the past six years, as has already been stated, a settlement of 2 to 3½ ft. In the light of existing conditions, and through experiences elsewhere on similar soils a total subsidence of 4 to 6 ft. in 10 to 12 years more under drainage and cultivation does not seem improbable. For soils of given depths the amount and rate of subsidence, our experiments disclose, are largely affected by the depth of water table. The deeper the greater and more rapid the subsidence, and the shallower the slower the settlement. Therefore, too deep drainage should be guarded against. And this not only from the standpoint of subsidence, but also because muck, when it becomes too dry, has the peculiar property of resisting the reabsorption of moisture, the continual replenishing of which is necessary to optimum plant growth.

The kind and intensiveness of cultivation of the land also affects both the amount and the rate of subsidence, and this factor, too, must be considered in designing a drainage system. The above appear from our experiments to be the two chief factors producing soil subsidence; to-wit: depth of water table and intensiveness of cultivation. There are doubtless many other contributing causes such as oxidation, advanced soil decomposition, etc., the combination of all requiring careful handling of much soil undergoing drainage. Nature's changes are slow and orderly. The artificially induced and sudden metamorphosis from water area to land area is bound to be accompanied by consequences which should receive close observation and continual watchfulness. The idea commonly entertained that muck soil through drainage is subject to only a few inches subsidence, is a completely exploded theory.

Drainage Layout for Muck Soils.—Based on observation of muck soil under the condition met with in the Everglades, the following conforms to the author's opinion of a satisfactory drainage layout for muck land such as heretofore described. Discharge capacities are represented by the equation $D = \frac{12}{1 + \sqrt{A}} + 16$. Under the following assumptions: "D" equals discharge in cubic feet per second per square mile; "A" equals area in square miles; Maximum water level in ditch, 1 ft. below ground surface; Depth of lateral ditches not less than 5½ ft.; Reduction of water level before beginning of rainy season, to not less than 50 in. below ground surface. Lateral ditch intervals, not over ½ mile. Farm ditch intervals not over 660 ft., depth not less than 4½ ft. Farm drains according to needs—110 ft. suggested interval. The foregoing refers to the collecting system. The larger ditches should be sufficient of course to carry the water brought to them by the smaller ditches; the same equation is applicable.

The above further necessitates giving due consideration to soil subsidence and the building of the ditches and canals sufficiently deep to compensate for loss from this source. In virgin muck soil 8 ft. or more in depth the ditches should be cut 8 ft. deep in order to have as much as 5½ ft. after 3 or 4 years of drainage and cultivation, and this minimum depth of 5½ ft. must be preserved, and can be through maintenance from time to time. Where partial subsidence has already taken place allowance may be made accordingly.

Ditches within reasonable limits and where practicable should be deep and narrow rather than broad and shallow. The sides should be as steep as the nature of the material will allow. Side slopes of ¼ to 1 stand very well in ordinary muck. The steeper the sides, the less trouble from weed growth, which is the most serious source of ditch deterioration in muck soil.

There are numerous other considerations in addition to that of maximum drainage efficiency, which will influence ditch design. The existence of rock at 4 to 5 ft. below surface would probably dictate broader, shallower lateral ditches to eliminate costly rock digging, but having greater discharge capacity. Also the matter of practical construction should always be borne in mind. Ditches of odd sizes, requiring many different sizes of machines to excavate, would almost certainly be more expensive than a system made up of standard ditches within the limits of the fewest different types of machines to dig, and not only first to dig, but forever to maintain. These are questions merely alluded to and cannot be discussed here.

Pointers on Painting Steel Water Tanks.—In a discussion of a paper presented last December before the New England Waterworks Association, Mr. Henry A. Symonds, consulting engineer, Boston, Mass., stated that the secret of first class painting of steel tanks was to be sure of a clean surface and to rub the paint out to a uniformly thin film.

The Relation of the Engineer to Public Health Work

There appears to be much uncertainty and misunderstanding as to the place of the engineer in public health work. This applies not only to the average citizen but also to engineers themselves. "What has an engineer to do with public health?" is a question frequently asked, according to C. M. Baker, Wisconsin State Sanitary Engineer. He answers this in a paper presented by him before the Engineering Society of Wisconsin at its recent annual meeting. The following material is taken from his paper.

Engineers have been employed in the United States Public Health Service for not to exceed ten years, but it is only within the last three or four years that any appreciable number of engineers have been engaged in public health work with the federal government.

The Organization for Public Health Betterments.—The foundation of any organization for the betterment of public health consists of a statistical department where all vital and morbidity statistics are more important from a purely public health standpoint. Without these statistics there is nothing on which to base the work.

The aim and object of all public health work is to prevent disease, but the matter of prevention depends upon the character of the disease. This necessitates a careful study of these statistics in order to determine which diseases are prevalent and where they exist, also, in some instances, possible causes. A department of preventable diseases to determine which diseases are preventable, and their causes constitutes the framework of the organization, while the body of the structure consists of the various departments organized for executing the work such as that of sanitary engineering, industrial hygiene, child welfare, and public health nursing. Covering the whole structure of the organization, as the roof of a building, should be a department of education, for public health work to be successful must be largely educational. There are three classes of preventable diseases with which a department of health has to contend.

(1) Those communicable by direct infection as, meningitis, chickenpox, smallpox, diphtheria, measles, poliomyetitis, scarlet fever, tuberculosis, whooping cough, venereal diseases, etc.

(2) Those communicable by indirect infection as typhoid fever, cholera, and other intestinal diseases, typhus fever, malaria, yellow fever, plague, hookworm, etc.

(3) Those preventable but non-communicable as the occupational and industrial diseases.

The Engineer As a Factor in Public Health Work.—The control of the first class of these diseases is principally the work of a physician, but the control of the last two classes depends mainly upon work of an engineering character. The intestinal diseases are controlled by providing adequate sewerage, pure water, milk and foods; typhus fever by extermination of lice which are instrumental in transmitting the disease; malaria and yellow fever by drainage and mosquito eradication; plague by rot extermination, and hookworm by proper disposal of sewage; while the industrial diseases are largely controlled by modifications in the process, by providing adequate ventilation, etc. It is thus apparent that the engineer is an important factor in public health work, but it is also evident that a physician is likewise necessary.

In view of the important phase of engineering work, some have gone so far as to contend that a sanitary engineer, trained in public health work, is better qualified as a health officer than a physician, and there is quite a strong feeling that engineers, properly trained, are at least fully as well qualified.

Why Physicians Predominate in Public Health Work.—In the beginning of modern public health work there were only a few sanitary engineers, and this work, because of its character, was naturally associated with the work of a physician. Physicians, therefore, took up and pushed this line of work in its inception, frequently because of their interest in public affairs, an interest which I regret to say has not been very prominent in the past among engineers, or at least, if engineers have been interested, they have been very inactive. Another very important reason for the majority of health officers being doctors is that every small community has its physician, while even now sanitary engineers are comparatively few, and aside from the engineer there are probably no other individuals so well qualified for public health work as physicians. The most logical procedure, therefore, has been to appoint physicians as local health officers. Necessarily, therefore, the medical profession predominates in public health work. This should not be misconstrued. Neither a sanitary engineer nor a physician, as such, is fully qualified to become a health officer until he has had special training or experience, but their preliminary training is basis for public health work. In other words they are more qualified than others to take up this work.

That sanitary engineers can become efficient health officers has been thoroughly demonstrated, but the number engaged in this profession is so small compared with those engaged in the medical profession that the sanitary engineer can make but a very small impression upon public health work as a whole.

Whether the engineer or the physician should be in executive charge of public health administration, depends upon the training and executive ability of the individual. In fact any other individual, properly trained, may become an efficient administrative officer in public health. The engineer doubtless receives more training as an executive than a physician. On the other hand, however, the physician meets the public to a greater extent, and has undoubtedly been more active in public affairs than the engineer, and furthermore, because of the preponderance of physicians, it is only logical that they predominate in public health work. The place of engineers in this work, as in other public affairs, depends largely upon their activity in this respect. There now appears to be a movement among engineers to become more active in general public affairs. If this duty had been recognized long ago by engineers, they would undoubtedly now occupy a more prominent position in the eyes of the public.

Relations of the Engineer to Health of Community.—We have discussed the work of the engineer directly engaged in public health work. Let us now consider the relation that engineers not engaged in public health work may have indirectly upon the health of a community, or upon health organizations. Water, sewerage, garbage and refuse disposal, plumbing, heating and ventilating, and industrial hygiene are some of the most important subjects affecting public health. They are also primarily engineering subjects; subjects that are being daily handled by engineers, and with which every engineer comes more or less in contact. The effect, therefore, that the engineer has upon public health depends largely upon the manner in which he handles these problems. Furthermore, by taking an active part in all public affairs he can increase his prestige, and because of his training he should be able to give sound advice in public health matters of an engineering nature, and should be an influence for the improvement of health in his community. The question is, what does he actually do?

Waterworks are designed by engineers; the source of supply is of vital importance both regarding quantity and quality.

There are numerous instances where engineers have designed and constructed sewers so as to discharge without purification into a stream a short distance above a water supply intake. Even though the water supply is purified, such a practice increases the load upon the purification plant, and very materially increases the potential danger that always exists where purification must be relied upon to remove dangerous pollution from a water. Furthermore, in the construction of sewerage systems, there appears to be a tendency among engineers to provide a minimum amount of purification.

While garbage and refuse disposal have only an indirect bearing on public health, there are included either directly or indirectly in all health departments, and are wholly engineering problems. Plumbing and heating and ventilating are also engineering problems that must be considered by health departments.

It has been previously stated that educational work is one of the most important factors in public health. What is the engineer doing along this line? When the consulting engineer is employed to design a waterworks or sewerage system for a municipality, does he always give proper consideration and impress upon the municipality the sanitary aspects of the problem? Does he impress upon the municipality officials the necessity of adequate purification of the water, and of proper treatment of the sewage? Too often these important factors are neglected.

Engineers are, of course, largely guided in their work by available appropriations and by the direction of higher officials. In this way they are frequently hampered and are unable to carry out the work as they desire, but if they were more insistent as a whole body in maintaining a higher standard of work, much better results could be obtained. Frequently a water purification or sewage treatment plant is properly designed and constructed by an engineer, but subsequent to the completion of this structure his connection with the project ceases and because of inefficient operation. due to lack of knowledge on the part of local officials the plant is a failure; as a result of which both public health and the prestige of the engineer suffer. For his own protection the engineer should thoroughly instruct the local officials in the operation of these plants, and should maintain certain supervision over their operation for some time, probably a year, after they are put in operation.

It may seem that these criticisms are too severe. Truly they do not apply to all, but they do exist to such an extent that many public health officials feel that engineers as a body have little or no interest in public health. It has been pointed out, however, that engineering plays a very important part in public health work. Obviously, therefore, the engineer can assist greatly in developments along this line. If engineers are to be given proper consideration in this line of work, however, they must take an active part in all public affairs, and use their influence in the betterment of sanitary conditions, not only in their own community, but also in connection with all lines of work with which they come in contact. Merely criticising doctors and public health officials for not recognizing the importance of the engineer is unjustifiable, and will not assist in giving the engineer the prestige that should be his.

Stream Pollution in Wisconsin

Some idea as to the extent of stream pollution in Wisconsin is conveyed in the recent report of the Sanitary Engineering Committee of the Engineering Society of Wisconsin by W. G. Kirchoffer, chairman. This report states that there are some 26 distinct watersheds comprising the drainage area of the state of Wisconsin, each one coursed by a stream of considerable size. Into these rivers and their tributaries are discharged the refuse and wastes from 160 public sewerage systems, 60 pulp and paper plants, 80 or more pea canneries, 55 or more condenseries, 124 gas plants and tanneries, 60 state and county institutions, and 55 chemical and glue factories and woolen mills, making a total of 594 definitely known plants contributing to the pollution of Wisconsin waters. These are in addition to some 3,000 minor waste disposal plants, such as those in connection with residences, stores, offices, public buildings, industrial plants, creameries, cheese factories, and school buildings, which, in the aggregate, are a factor in polluting streams, rivers, lakes, or other sources of naturally safe water supplies.

About 53 out of 160 communities having public sewer systems have provided for sewage purification by treatment systems. The majority of these, however, are of questionable efficiency because of faults in design and operation. A small percentage of the pulp and paper plants have provided for partial purification of the water-carried wastes. About 30 per cent of the pea canneries have satisfactory treatment systems. Approximately 50 per cent of the condenseries dispose of their wastes through treatment systems. Approximately 500 of the 3,000 creameries and cheese factories employ purification systems in connection with their waste disposal. So far as known but a small percentage of gas plants and tanneries employ purification systems. The majority of the state and county institutions dispose of their sewage in a satisfactory manner. A very small percentage of the chemical and glue manufactories and woolen mills have given the purification of wastes attention in the way of providing for a satisfactory degree of purification prior to discharge into rivers and streams or other bodies of water.

The estimated water-carried wastes from the 60 pulp and paper mills is approximately 30,000,000 gal. daily; from the pea canneries 5,000,000 gal. a day; from the 55 condenseries 7,000,000 gal.; from the 124 gas plants and tanneries 5,000,000 gal.; from the state and county institutions, nominal; and from the 55 chemical and glue factories and woolen mills, about 5,000,000 gal.

In addition to this, the minor waste disposals, some 3,000 in number, discharge 3,000,000 gal. daily, making altogether a total of sewage and waste disposal of huge proportions.

Mosquito Suppression at Cambridge, Mass.

In June, 1918, the city council of Cambridge, Mass., appropriated $5,000 for the suppression of the fly and mosquito nuisance. The U. S. Navy Department also made an allottment of $1,000. The work was carried out under the direction of L. M. Hastings, city engineer. In his annual reports for 1919 and 1920 Mr. Hastings gives an account of what was done.

Work began June 18, 1918, and was continued until Oct. 18, 1918, along the following principal lines.

There are about 2,270 street catch basins in the city. These were dosed with a small quantity of oil regularly every two weeks, giving about 20,000 oilings for the season.

In addition to these, about 30 ponds and pools in which it was likely that mosquitoes would be propagated were oiled nine times during the season. Prior to this oiling, large areas of heavy growth of sedge and rank grass were cut on the borders of the ponds. In all about 2,200 gal. of fuel oil was used in the various ways mentioned.

In three sections, lands which were low and covered with shallow water were drained by ditching and the construction of culverts. In this work about 5,900 ft. of ditching was dug and about 200 ft. of wooden culvert were constructed.

Where possible, low areas were filled with ashes and other material. Considerable time was also devoted to reducing the opportunity of mosquito propagation in old cans, pails, pans, etc., found at many dumps, by perforating the bottom of each vessel or burying it.

In the above work, the board of health co-operated by preparing a circular relating to this subject of which 20,000 copies were printed and distributed to the householders and inhabitants of the city.

The amount expended on the work is as follows:

For labor	$2,916.69
For hire of teams, auto and repairs	860.28
For oil	245.37
For miscellaneous supplies	346.89
Total	$4,369.23

The satisfactory results obtained in 1918 in the efforts to suppress the mosquito pest led to the continuation of the work during 1919. The sum of $3,000 was appropriated and the work was carried on during the season from about May 1 to Oct. 15, along the same lines as in the previous year.

The drainage ditches dug that year were opened up and when necessary cleaned out. The drainage ditches on the lands adjoining the esplanade in the vicinity of Fowler street were extended about 670 feet and about 120 feet of wooden culverts were built. All the ponds, pools and ditches with stagnant water were systematically oiled.

During the early part of the season all the catch basins, about 2,300 in number, were oiled every two weeks. In the latter part of the season, owing to depleted appropriation, the number of men employed was reduced and the time between oilings of the catch basins was lengthened.

A few invasions of mosquitoes were experienced during the season apparently coming from sections outside the city limits. The amounts expended were:

For inspector labor	$2,995.39
For hire of auto, team and repairs	776.09
For oil	326.92
Miscellaneous	91.03
Total	$4,189.43

Expense Ratios of Waterworks Operations of Pasadena, Calif.—The expense ratios for the Pasadena Water Department and cost of water sold are summarized as follows in the 7th annual report of the department, covering the year ending July 30 last:

Year ending June 30, 1920.	Percentage of total expense.	Percentage of water revenue.	Cost of water per 100 cu. ft. (in cents).
Gravity supply expenses	2.80	2.10	.21
Pumping expenses	21.62+	16.20	1.59
Water production	24.42	18.30	1.80
Distribution	7.35	5.51	.54
Commercial	9.57	7.17	.70
General	7.40	5.54	.54
Operation & maintenance.	48.74	36.52	3.58
Depreciation	29.17	21.86	2.14
Interest	22.09	16.55	1.62
Total	100.00	74.93	7.34

Operating Data of Wurl Screen and Imhoff Tanks

Interesting data on the removal of solids by the Wurl screen and Imhoff tanks based on [illegible] operation of the Plainfield, North Plainfield and Dunellen (N. J.) joint sewage disposal works were given by Mr. John D. Downes, Superintendent of the plant, in a paper presented Feb. 18 at the annual meeting of the New Jersey Sewerage Works Association. The paper follows:

General Features of the Plant.—The plant was designed for 40,000 people, and is of the separate domestic type. The sludge separating portion of the plant originally consisted of six Imhoff tanks, each with a total flow length of 64 ft. and a total width of 25 ft. Each tank has four longitudinal settling compartments with effective width of 5 ft. each. Two gas vents, each 22 in. wide in the clear, extend the entire length of the tank. The walls extend perpendicularly to 5 ft. 6 in. below the flow line. The slopes, about 1 on 1, extend to the slot 11 ft. below the flow line.

The tanks were put into operation at the end of November, 1916, and operating experiences during the ensuing year indicated the necessity of removing the coarser solids, paper, fiber, hair and fecal matter from the sewage before it was admitted to the tanks; such solids not being amenable to treatment in the tanks. For the purpose of removing these coarse solids a Wurl screen was added to the sludge separating equipment and was put into operation in September, 1918.

The Wurl screen is essentially a brass disk, 10 ft. in diameter, revolving on a shaft inclined 15°. The disk is perforated with some 12,000 slots, each 1/16 by 2 in., and is submerged to about half its depth in the flowing sewage. The solids, which are caught on the surface of the screen, are swept into a trough by the revolving brushes which continually scour the unsubmerged portion of the disk. A 1-HP. electric motor which can be adjusted to run at speeds from 600 to 1,800 r.p.m. operates the screen mechanism.

Operating Data for Screen and Tank.—Table I gives information concerning the suspended solids in p.p.m., as determined by the Gooch crucible method, the number of cubic yards of digested sludge removed from the tanks (measured by shutting off the tank during drawing of sludge and measuring the depression of the water level), the number of cubic yards of air-dried sludge removed from the drying beds (cart measurement), the sewage flow in million gallons and the number of house connections at the end of each month.

Two of the municipalities contributing to the plant were installing sewers for the first time, and the third took in large sections of sewers, so that the increase in number of connections during the first year was very rapid. In order to make the complete sludge data of the four years available for estimation of per capita and per connection quantities, the number of connections at the end of each month have been added together and multiplied by 30 to get the number of connection days contributing the observed quantity of sludge; five times this figure is considered the number of person-days; this figure checks up well with the known population.

Screenings were measured in a wagon, most of the free water having drained away before measurement was made. The dry solids = 11 per cent.

Sludge Accumulation and Disposal.—At the end of the fourth year of operation a sludge survey of the digestion compartments indicated that there remained at that time 750 cu. yd. of sludge. In three of the tanks the sludge was at the bottom of the hoppers, and in the other three it was almost entirely floating at the surface of the gas vents (this in spite of constant effort to beat it down).

In addition to the above solids there has been removed from the gas vents a quantity of partly digested sludge estimated at 1,000 cu. yd. This was removed by pumping and by wheelbarrows and ranged in consistency from a watery 96 per cent sludge to a viscous 88 per cent mass, containing much hair and fiber.

The sludge digestion portion of the plant consists of 10 sludge hoppers to each tank—these are in two rows of five each—directly beneath the gas vents. The depth between the slot communicating with the settling compartment and the top of the hoppers is 6 ft., providing a total settled sludge capacity of 57,000 cu. ft.

With any operating program, which we have been able to develop, there accumulates in time a mass of floating sludge of so slight a specific gravity that it will never settle. This does not refer to the thick, viscous slude appearing at the top of the gas vents and which may be wheeled off in wheelbarrows, but to a sludge of 95 per cent water content and thoroughly digested. This sludge, floating throughout the entire depth of the digestion compartments and gas vents, is naturally carried back via the slots to the settling compartments by various currents. The result is a black film on the surface of the settling compartment and a very poor looking affluent with an avidity for oxygen which is a serious drain on the sprinkling filter.

It now appears that it will be necessary to pump out the upper portions of the digestion compartments at least once a year, in order to dispose of this digested but unsettleable sludge.

With regard to sludge drying, we find that with 35,000 connected population, we have approximately 4,000 cu. yd. of sludge to be removed from the tanks each year.

Our experience shows that it is not economical to put over 9 in. of wet sludge on a bed, since this quantity will dry in a week or 10 days of good weather, while any greater quantity will require a time measured in weeks.

It is surprising to find that, in spite of the fact that a coat of sludge 9 in. thick will become spadable in a week or 10 days of good drying weather, under actual climatic conditions, we have averaged only a scant 6 dryings per year. The figures for three years are 5.8, 6.0 and 5.8 dryings per bed a year.

Therefore to dry 4,000 C. Y. = 108 cu. ft. of sludge per year, requires 108,000 ÷ .75 = 144,000 sq. ft. of drying surface per year, and 144,000 ÷ 6 = 24,000 sq. ft. drying area required to take care of 35,000 people under local weather conditions. This amounts to .686 sq. ft. per person.

Operating Costs.—Operating costs for 1920 outside of supervision and organization charges are shown in Table II. It would hardly be worth while to go into operating costs for the other three years on account of the sliding scale value of the dollar, but the proportional distribution will be very nearly the same as for 1920.

It is interesting to note that outside of interest charges the comparative costs as between screening and removing the

TABLE I.—OPERATING DATA FOR SCREEN AND TANK.

Year.	Suspended solids, P. P. M. Screen effluent.	Suspended solids, P. P. M. Imhoff effluent.	Sludge from— Tanks. Cu. yd.	Sludge from— Beds. Cu. yd.	Screenings Total cu. ft.	Screenings Daily cu. ft.	Flow Total M. G.	Flow Daily M. G. D.	House connections. 4,500—Start 5,400 6 mos.
1917	[illegible]	[illegible]	1,609	586	......	..	939	2.6	5853
1918	[illegible]	[illegible]	3,520	1,009	....	..	[illegible]	3.4	6398
1919	(+) 142	[illegible]	1,069	[illegible]	18,250	50	1,301	3.6	6804
1920—									
December	[illegible]	71		12	1,220	47	110	3.6	6905
January	[illegible]	70	.	.....	1,362	[illegible]	109	3.5	6909
February	123	69		28	1,273	44	100	3.5	6912
March	116	[illegible]	415	. ..	1,393	46	[illegible]	4.3	6921
April		[illegible]	230	97	1,383	[illegible]	113	3.8	6943
May	[illegible]	80	248	61	[illegible]	44	105	3.4	6969
June	[illegible]	57	631	202	[illegible]	[illegible]	93	3.3	6993
July	175	77	475	92	1,426	46	[illegible]	3.5	7003
August	152	48	523	129	[illegible]	46	97	3.4	7036
September	174	65	[illegible]	251	[illegible]	41	96	3.2	7076
October	[illegible]	[illegible]	364	109	[illegible]	52	[illegible]	3.1	7078
November ..	[illegible]	82	346	69	1,359	45	[illegible]	3.1	7111
[illegible]	161	66	3,807	1,140	16,351		12,430	.	....

Sludge from tank [illegible]

[illegible] 1917, 1918, 1919 [illegible] due to mixing and comminuting effect of screen on the solids. Samples during [illegible] were taken before [illegible].

[illegible] settleable solids [illegible] total settled.

Screenings indicated in above table amount to .0015 cu. ft. per person day.

[illegible] cu. ft. per person day.

objectionable solids from the tanks by hand are just about equal; that is to say, the time now spent by a watchman on the screen and the cost of power about equal the cost of labor in removing the coarse solids. The plant, however, is much more workable and the nature of the labor much less objectionable when the solids are removed before reaching the tanks.

Outside of the Imhoff tanks and the Wurl screen, which, in view of the above statement, must be considered as a charge against the tanks, one man could do all that is necessary about the plant. To this other work we will suppose the highest paid laborer to be assigned and charge all ordinary labor to care of screen and tanks and to sludge removal.

TABLE II—COST OF OPERATION -1920.

	Total.	Chargeable to screen, tanks and sludge removal.
Labor	$6,437.66	$4,637.66
Heat, light, power, etc	1,131.39	240.00
Supplies, tools	1,017.59	1,017.59
Machine repair, tractor, spreaders, etc.	247.05	247.05
Screen, motor repair	186.28	186.28
Gasoline, oil, etc	370.80	370.80
	$9,390.77	$6,699.38

Expressed in man hours, the labor required to operate the plant is:

For general attention to plant	2,450 man hours per year.
For night watch on screen	5,630 man hours per year.
Care of tanks	5,820 man hours per year.
Drawing and hauling sludge	1,242 man hours per year.
Or general plant	8 hours week days
Watch on screen at night	16 hours week days and Sundays
Care of tanks	17 hours week days.
Drawing and hauling sludge	4 hours week days.

Notes on Operation of Wurl Screen.—The screen has run practically continuously for two years. The first set of screen cleaning brushes lasted exactly two years before requiring replacement. The speed control apparatus on the motor is the only thing that has given any trouble—$151.01 has been expended to date on this item. Two broken brush flanges, cost for replacement, and a duplicate of each for stock, $38. The current consumption is from 9 to 12 K. W. H. per day.

The maximum (working) loss of head on the screen is 13 in., and the capacity of the screen with 13 in. loss of head and full screen speed (about 1 r.p.m.) is at the rate of 4,750,000 gal. per day.

Calculating Evaporation Loss from Storage Reservoirs of Hydro-Electric System

Daily calculations of the loss by evaporation from the storage reservoirs of the San Joaquin Light & Power Corp., of Fresno, Calif., are made during the months of the year when evaporation is appreciable. The method of making these measurements is described as follows by Mr. R. C. Denny, in an article in the Feb. 8 issue of Power:

To measure the evaporation, a galvanized-iron pan 7.45 ft. in diameter and 2 ft. deep, with a ¾-in. iron pipe rim, was made and placed in the reservoir near the gate tower. The pan is provided with a hook gage and filled up to this gage with water. A pail was made holding just enough water to raise the level 0.002 ft. when poured into the pan. Water is poured into the pan each morning to make up for that evaporated during the previous day, and account is taken of the number of pailfuls needed to bring the water in the pan back to the same level as shown by the gage. Having been telephoned the reservoir level and the number of pailfuls used, the dispatcher ascertains from his curve the area at that particular elevation and applies the formula,

$$\text{Number of pails} \times 0.002 \times \text{area of reservoir}$$
$$= \text{acre-feet evaporation}$$

The daily evaporation from the Crane Valley reservoir has run as high as 39 acre-feet during the summer months, with the reservoir at the higher elevation—110 ft. Some conception may be gained of the enormous quantities of water evaporated daily by thinking of it in more familiar terms. For instance, a train of 1,061 tank cars, each of 12,000 gal. capacity, would be required to contain 39 acre-feet, the quantity lost in a single day.

Men Needed for Corps of Civil Engineers of Navy.—The Secretary of the Navy has announced that applications would be received at the navy department to fill vacancies in the corps of civil engineers of the navy with the rank of junior grade lieutenant. Preliminary examination papers must be submitted by candidates before May 16. A final examination will be given later. The initial salary is approximately $3,200 per annum.

Air in Gravity Water Mains*

By J. W. LEDOUX,
Consulting Engineer, Philadelphia, Pa.

Nearly every water-works superintendent has experienced trouble in connection with some phase of air in pipes. A leaky suction pipe often reduces the plant efficiency materially, and sometimes results in serious damage to the pumping machinery. Where the discharge pipe is perfectly tight, if a small quantity of air be pumped with the water it is likely to accumulate on the summits and appreciably reduce the capacity of the pumping main, or, what is the same thing, increase the frictional head due to the reduced cross-section of the pipe at the summits. The remedy is to prevent the ingress of air at the pumping plant; but even at best more or less air is entrained with the water, and under reduced pressure at the summits this air may at times accumulate, and then the only remedy is to provide on these summits automatic air valves. However, this difficulty is not common, for several reasons. Unless it enters the pumping main in large quantities it is generally carried along with the water, and if an air obstruction develops the automatically increased pumping pressure tends to drive it over the summits by attrition. Also, air will escape through apertures too small to show water leaks, and there are usually enough of these to prevent noticeable trouble from pumping discharge mains. This property of air is often the cause of leaks, for in discharging at a high velocity it increases the size of the aperture by washing out fine particles of material that would remain in place if the pipe were full of water.

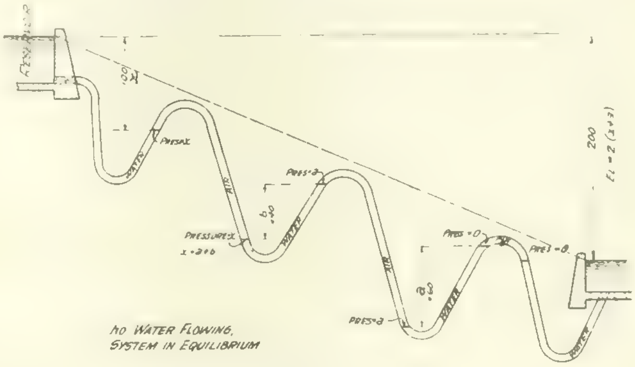


Fig. 1.

While the cushioning effect of air in mains often prevents serious water hammer, on the other hand its sudden escape at a high velocity, as sometimes happens, will produce serious water hammer.

The accumulation of air in summits of gravity mains has frequently resulted in the complete interruption of the supply on large portions of the system; and sometimes this phenomenon is troublesome and difficult of correction.

Examples of Stoppage of Supply by Air Pockets.—In one case in the experience of the writer a 14-in. main extended from a distributing reservoir, at elevation 628, across a valley the elevation of which was 150, to the opposite hill at elevation 550, where there was a considerable amount of population and very variable topography. Branches from this main extended at right angles in both directions to lower elevations. It was found that no water could be furnished on one of these branches, as was evidenced by the complaints of the consumers. The spigots were opened in houses, and the water would not flow even at the ground floor. After many hours' investigation, a pocket of air under pressure was discovered at one of the summits, and as soon as this was released the supply was immediately resumed.

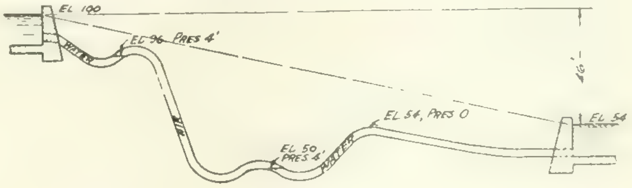


Fig. 2.

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*Paper presented Nov. 10 at a meeting of the New England Waterworks Association.

Another case consisted of a [illegible] an impounding reservoir eight miles to two standpipes supplying the railroad service. It was found, one afternoon, that no water would flow into the standpipes, and it was immediately assumed that somebody had closed a valve or that the reservoir was empty, because there had not been experienced any trouble since the line was installed several months previously. An inspection was made; air valves were opened all along the mountain at the various summits; no water flowed and no air came out of the main. It was finally learned that, on the day before, a valve had been closed near the reservoir to make some slight repair on the line; on inquiry it was found that this valve had been reopened, and this was verified. It had been the intention to locate automatic air valves at all the summits. One of these summits was close to the impounding reservoir. Finally, this air valve was examined and to the surprise of every one it was found disconnected and lying in the valve pit. On opening the air valve connection the air escaped and the water began to flow freely. This particular summit was so close to the reservoir and so small as compared with the others on the line that no one suspected that trouble existed at that point.

The diagram, Fig. 1, illustrates the principle.

In this case the impounding reservoir is shown 200 ft. above the distributing reservoir, and under these conditions no water can flow through the line until the air is relieved at the summits.

Figure 2 illustrates about the conditions that occurred in the gravity supply to the railroad tanks. The above examples show conditions of static equilibrium and a balance which is frequently very delicate. This condition is not likely to take place with pumping mains, where the pressures fluctuate, but is characteristic of fixed levels of water as occur in gravity mains. At least, that has been the experience of the writer.

One of the most important conditions where serious damage can be caused on a pipe line is in the case of a large wood or steel pipe laid over summits and valleys. If, due to water hammer or defect in the pipe, an actual split or break of the pipe takes place in the valley, permitting a large quantity of water to discharge faster than the water can pass over the summit to keep the pipe full, a partial vacuum occurs, and unless the pipe is designed to resist it, collapse will take place. The only remedy for this danger is to maintain a sufficient number of poppet valves designed to take large quantities of air into the line automatically; some very serious damage has taken place, due to the absence or insufficient size of these automatic poppet valves.

A vacuum is sometimes caused in a pipe line for another reason: Let us suppose a large wood or steel pipe line extends from a distributing reservoir down the hillside to a flat 200 ft. below, and that the pipe line is full of water but not flowing. Now, if between the base of the hill and the distributing reservoir a valve be shut, the pressure at the downstream side of the valve will at once drop to almost a complete vacuum, because this part of the pipe line is relieved of the atmospheric pressure acting on the distributing reservoir. Under these conditions collapse of the pipe is likely to take place.

How to Fill a Gravity Pipe System.—In connection with this subject, it may be well to call attention to the best method of filling a gravity piping system that has been for some cause emptied. The writer has heard many experienced water-works men advocate filling the pipe line by sections. This is a very bad practice. The best method is to open air valves at all the summits, and open the blow-off valves in all the hollows and a sufficient number of hydrants in the town. Then the valve at the impounding reservoir is opened a sufficient amount to fill the line in a predetermined time. As soon as the water appears at the first blow-off and flows full, this is shut, and as soon as it flows full at the second blow-off, that is also shut, and so on, until the water appears at the city hydrants, shutting the low ones first and following them up until the high ones are shut; finally, the air valves on the line are closed and the line is in service, and no danger of water hammer has been experienced, and the line is filled in a shorter time than can be done by any other method.

Rainfall in Massachusetts.—The normal yearly rainfall in Massachusetts as deduced from long continued observations [illegible]

Pipe Extension Charges

Charges for pipe extensions, although but a small part of the entire charges for public service, is frequently one of the most vexing to water works superintendents. With the present conception of a public utility, whether publicly or privately owned, it is not fair for the utility to incur the cost of extensions which do not pay, for it places an unfair burden upon existing consumers.

A man about to build a house 1,000 to 1,500 ft. from the present mains asks for an extension to give him service. The total amount that he will pay for water under existing rates will but a drop in the bucket compared to the total revenue required to pay a fair return on the extension. This problem of ascertaining the fair return on the extension is discussed at length by Nicholas S. Hill, Jr., consulting engineer, 112 East 19th street, New York, in a paper presented before the recent meeting of the New England Water Works Association. The following is an abstract of this paper.

The problem of ascertaining the fair return on the extension proper, the taxes on the extension proper, and the depreciation on the extension proper is simple, but the allocation of a fair proportion of the gross cost on the entire system to the extension proper is not so easy.

The greatest stumbling block in connection with the problem of charging for extensions is the desire for mathematical accuracy. The problem is not one of ascertaining the proper charge to the last mill, but to allocate the costs fairly so that the extension will pay its just and reasonable proportion of the general expenses of the plant.

If the rate structure of a utility is properly developed and cost is distributed between fixed or static costs and proportional costs the problem is not so difficult. As a rule, the proportion of the so-called fixed charges on the property, that is, the proportion of the fair return, taxes and depreciation, on a plant which may properly be allocated to fixed service or static costs varies between 30 per cent and 50 per cent in an average water works plant. Similarly, the proportion of operating expenses on the entire plant chargeable to fixed service or static costs varies between 15 per cent and 40 per cent. The total fixed service or static costs, which do not vary in proportion to the amount of service taken but remain stationary whether service is taken or not, amount to from 20 per cent to 40 per cent of the total cost of service in an average water works.

How to Determine Proper Charges for an Extension.—Briefly, the rules for determining the proper charge for an extension are as follows:

1. Ascertain the cost of the extension.
2. Determine the annual cost of the extension, including:
   a. Fair return on the cost of extension.
   b. Taxes on the extension.
   c. Depreciation on the extension.
   d. Maintenance on the extension.
3. Take from 20 per cent to 40 per cent of the gross cost of service (gross cost of service = fair return, taxes, depreciation reserve and operating expenses) as the proper portion chargeable to fixed service or static costs.
4. Divide the total fixed service or static cost by the number of inch-feet in the distribution system to determine the proper fixed service or static charge per inch-foot of main
5. Multiply the number of inch-feet in the proposed extension by the fixed service or static charge per inch-foot as determined to ascertain the fair proportion of fixed service or static costs which should be allocated to the extension.
6. Add the fixed service or static charge for the extension to the costs chargeable to the extension proper to obtain the total annual cost chargeable to the extension.

Payment for Extension.—Now comes the question as to how the consumer is going to pay the cost of an extension, and in my judgment it is better to have a flexible rule by which the individual preference of the applicant or guarantor for the extension may be satisfied. Some prefer to pay a sum sufficient to cover the cost of the extension at the time the extension is made. Others prefer to pay an annual sum equal to the estimated annual charge for the extension, or, in other words, to pay for the extension in installments. Some water works allow the applicant to pay for the entire cost of the extension, but such a payment does not cover the cost of an extension as it saves the water works nothing but the interest on the money which it would have to secure to pay for the extension. If the guarantor is allowed to pay for the cost of the extension it should be understood in the extension agreement that the difference between the revenue actually received from the extension and the fair annual cost of the extension as determined shall be deducted year by year from his payments until such time as the revenue from the extension is sufficient to pay the annual charges against the extension, and that there will be returned to him only the net balance due him after deducting the total annual payments from his deposit.

A better way to handle a flat payment is to estimate what the total annual charges on the extension will be for a covering period, say ten years, and to require the guarantor to deposit this sum with his extension agreement. In such a case the extension agreement will provide that only the actual differences between revenues from the extension and charges to the extension will be deducted, and any balance remaining at the termination of the extension contract will be refunded to the guarantor.

Another way, as I have already suggested, is to have the guarantor guarantee the annual revenue required to pay the annual charges for the extension, and if this is done it is necessary for the guarantor to furnish security so that the water works may be assured that the annual charges for the extension will be paid.

Revenue from the Extension.—As soon as an extension goes into service it usually pays some revenue. Statistics which I have collected on different water systems indicate that a large percentage, possibly 80 per cent or 90 per cent, of all extensions pay the extension charges within ten years. It is undesirable to have long extension agreements as it increases the number of such agreements outstanding unnecessarily, making unnecessary bookkeeping and unnecessary trouble. Moreover, there is some question as to whether or not a special extension does not within a certain reasonable time, whether it pays or not, become a part of the distribution system, so it is usually a good plan to agree to return the balance due from a cash deposit, or to release the bond under the annual payment plan, at the end of ten years. The water works will suffer very little loss on this basis and it removes many causes of complaint against extension charges. The extension contract should provide in any event that it will be automatically cancelled whenever the revenue received from the extension equals or exceeds the amount required to pay the annual charges on it. In the case of a cash deposit the balance due is returned at the period of cancellation whenever it occurs, and in the case of a guarantee the bond is cancelled in the same way. In that way the extension takes its place as a permanent part of the distribution system as soon as it commences to earn sufficient to carry it and it ceases to be a special extension.

There is one more point that I should touch upon and that is: What revenues should be deducted from the gross charges above outlined? The methods of charging for service are so different in different water works at this time that it is almost impossible to make a general rule on this question. I can do no more than outline the principle involved.

In the case of many extensions a water works will be immediately possessed of the income from the hydrants set on the line. If the entire fire service revenue of a water works is obtained from hydrant rentals it would be unfair to deduct the entire revenue from hydrants from the extension charge as a portion of this charge goes to repay the water works for the fair return, interest, depreciation and maintenance of the hydrant and its connections.

Where fire service charges are paid on the inch-foot basis the inch-foot revenue on the extension is a proper deduction. Where the hydrant charge is a nominal one and only sufficient to cover the fair return, depreciation, taxes and maintenance of the hydrant, the hydrant charge should not be deducted. The revenue which a water works receives from consumers along a line cannot all be treated as a proper deduction from the extension charges. A sufficient amount should be reserved from the water service revenue along the extension to pay for a fair return, depreciation, taxes and maintenance of the meters and service connections as well as the inspection, repairs and renewals of meters, and the reading and billing of meters. This will usually amount to from 40 per cent to 60 per cent of the minimum charge. The rule in relation to water service revenue from consumers along the line should be, therefore, to deduct 40 per cent to 60 per cent of the minimum charge from the water revenue received from each consumer and apply the remainder as a credit to the extension charges.

Hydrogen Ion Concentration of Water*

By R. EDMAN GREENFIELD,
Chemist, State Water Survey Division, Urbana, Ill.

What is hydrogen ion concentration and why is it of interest to waterworks men? The purpose of this paper is to answer that question. It has been found by a large number of experiments carried out in the past 30 to 40 years, that any acid when put into solution in water tends to break apart into the hydrogen ion and other ions of which it is composed. In the case of hydrochloric acid, hydrogen ions and chloride ions would be produced. Acetic acid gives hydrogen ions, and acetate ions a rather complex radical which we abbreviate Ac. Boric acid gives hydrogen ions and borate ions. We call this splitting up into ions, "ionization."

It has also been proved that not all acids ionize to the same extent. For example, in the hydrochloric acid solution, the hydrochloric acid ionizes about 90 per cent, but the acetic acid only ionizes about 2 per cent, and the boric acid ionizes only very slightly—about 0.005 per cent. An acid which ionizes greatly, such as hydrochloric, we call a strong acid, and it will have a very sour taste, and the ability to smart and burn the skin, and will give an acid color to all indicators. Those that do not ionize to such a great extent we call weak acids, and we find that the above-mentioned properties vary in intensity, according to the amount of ionization.

What the Hydrogen Ion Concentration Is.—From this reasoning we see, therefore, that the sour taste and ability to change indicators, depends not upon the total amount of acid per unit volume, but upon the total amount of ionized hydrogen per unit volume. And that is what the hydrogen ion concentration is: The total amount of ionized hydrogen per unit volume of the solution under consideration.

Alkalies ionize in a similar manner, as do all salts. The properties of the alkalies depend upon the extent of the ionization in a manner similar to the acids.

In most natural water we find carbon dioxide or carbonic acid in solution. This, like the boric acid, is a very weak acid, but it is an acid and gives a definite hydrogen ion concentration. This hydrogen ion concentration has recently attracted much attention. Biologists have found that the small plants and animals growing in water are much affected by changes in it. Some organisms are unable to exist in certain streams because of too high or too low hydrogen ion concentration. For this reason considerable interest is attached to the determination of the hydrogen ion concentration of surface waters.

One way of making this determination is by means of indicators. An indicator is selected which changes color at about the hydrogen ion concentration that the water is thought to be, and a small portion is placed in a solution of known hydrogen ion concentration, while an equal amount is placed in a sample of the water being examined, and then the colors are compared. If the color is the same, the hydrogen ion concentration of the water is the same as that of the known solution; if they are different, known solutions with different hydrogen ion concentration are tried until a match is obtained. Making comparisons in this way, and having at hand a selection of indicators and a set of solutions of known compositions, the hydrogen concentrations of which vary in a progressive manner; we are able to make these determinations quite accurately. There are other (and for some purposes better) methods of making these determinations, but it is not the purpose of this paper to go into those methods.

Hydrogen Ion Concentration as a Factor in Corrosion of Metals. — The hydrogen ion concentration also has a great deal to do with whether or not water will corrode metals. If we were to drop a piece of zinc into the hydrochloric acid, which has a high hydrogen ion concentration, we would see a good deal of gas rising, indicating that the metal is dissolving or corroding rapidly. If we were to drop zinc into acetic acid, which has a lower hydrogen ion concentration, there is also an evolution of gas, but not nearly so much. A boric acid solution, which has a very low hydrogen ion concentration, would have no apparent effect on the zinc.

We have always known that free carbon dioxide or carbonic acid in water would cause the water to be corrosive, but it is now obvious that the corrosive effect is to a considerable extent due to the hydrogen ion concentration built up by the carbonic acid. Two waters containing the same amount of free carbonic acid do not necessarily have the same hydrogen ion concentration, and therefore do not have the same corrosive action.

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*Abstract of a paper presented March 23 at the joint meeting of the Iowa and Illinois sections of the American Waterworks Association.

The hydrogen ion concentration produced by an acid varies inversely with the concentration of the other ion with which the hydrogen is associated in the acid. A water that contains 10 parts per million of carbonic acid will have a much higher hydrogen ion concentration, and therefore be more corrosive, than one containing the same amount of carbonic acid and, say, 200 parts per million of carbonates, for the carbonates (such as calcium and magnesium carbonates) also ionize to give carbonate ions and calcium or magnesium ions. This increase of carbonate ions serves to decrease the hydrogen ion concentration. This effect, which is called the common ion effect, can be illustrated by means of acetic acid:

Take a test tube containing acetic acid, and an indicator which the acetic acid causes to show its acid color, and add a small amount of sodium acetate, a salt of acetic acid. This addition of sodium acetate serves to increase greatly the concentration of the acetate ions, and you will see from the almost immediate change of color of the indicator that this has caused a decided decrease in the hydrogen ion concentration.

We see, therefore, that a study of the hydrogen ion concentration of natural waters may serve to throw some light upon the probable effect of the waters upon metals. We also see that the same information cannot be obtained by simply determining the total amount of carbonic acid which the waters contain.

Controlling Coagulation and Water Softening Reactions.—The third point of interest is the precipitation of the alum in the coagulation of water preliminary to sedimentation and filtration. The hydrogen ion concentration is of importance, since, if the water is too acid or, as more commonly stated, deficient in alkalinity, the alum will be precipitated incompletely or not at all, making the use of lime necessary.

Since this precipitation of alum depends upon the hydrogen ion concentration of the water, the proper control of the hydrogen ion concentration should be all that is necessary to obtain satisfactory coagulation results. It does not seem too much to hope that very soon automatic machines will be developed which will be controlled by the hydrogen ion concentration of the treated water, and which will regulate the dosage of alum and lime that is to be added to the water.

The precipitation of calcium and magnesium in a water-softening reaction is very similar to the alum coagulation, and it would seem that in this case the controlling of softening plants by means of the hydrogen ion concentration might not be too much of a chemist's dream.

The Illinois State Water Survey Division is at present engaged in studying the last three reactions with a view to determining the changes in hydrogen ion concentration which take place throughout the progress of the reactions, with the hope that accurate information on this point will be of value in working out better methods of control.

Cost of Icing Drinking Fountains.—The city of Cambridge, Mass., maintains nine ice water drinking fountains in public locations. The cost of furnishing these fountains with ice during the summer months for 16 years is shown in the following summary, abstracted from the annual report of the Cambridge Water Department for the year ending March 31, 1920:

Year.	Total cost	Average cost [illegible]
[illegible]	[illegible]	$1.20
[illegible]	514.18	.94
[illegible]	[illegible]	1.57
1907.	[illegible]	[illegible]
[illegible]	705.99	1.04
[illegible]	[illegible]	1.15
1910.	712.65	1.24
1911.	731.20	1.34
1912.	918.75	1.25
[illegible]	970.81	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	719.83	[illegible]
[illegible]	623.64	.79
[illegible]	[illegible]	1.37
[illegible]	1,216.04	1.57
[illegible]	1,086.17	[illegible]

Arch Action in Curved Dams*

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In general, arch dams have been designed by means of the so-called cylinder formula. It was assumed that all the water pressure be supported by horizontal arching and that the the arch thrust in any horizontal dam slice could be calculated by means of the relation:

Arch Thrust = Water pressure × Radius of Extrados.

The stresses were then obtained by dividing the arch thrust by the area of the cross-section of the arch. The gravity or cantilever action, which, of course, exists besides pure arching, was mostly neglected or simply assumed as increasing the strength of the structure to an unknown degree.

As a matter of fact, the cylinder theory applied to arch dams, is defective in several ways. First, it indicates a maximum arch thrust near the base of the dam, although it is evident that no arching can occur there and the arch thrush vanishes. Second, the arch thrust at the crest would appear to be zero, as there is no water pressure at that elevation, while in general the deflections of arch dams are a maximum at the crest, indicating also the occurrence of correspondingly large stresses to produce such deflections. Therefore, it is evident that the cylinder theory is 100 per cent wrong, both at the base and at the crest of every arch dam.

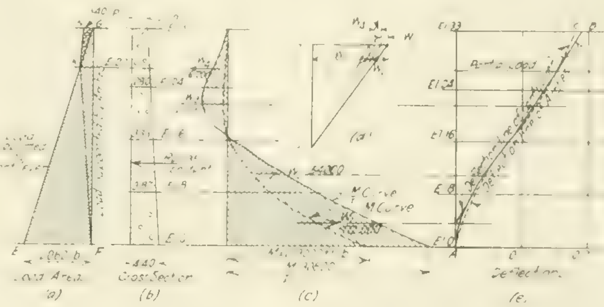

Fig. 1.—Drawing Showing Application of Graphical Method to Design of Wooling Dam.

Investigations made by the writer have shown that in most of the existing arch dams evidently a much higher percentage of the water pressure is carried by vertical cantilever action; that is, by gravity, than by horizontal arching. These conclusions are substantiated by similar investigations made by B. A. Smith, and published in the Proceedings of the American Society of Civil Engineers (March, 1920). Mr. Smith considers an arch dam as a portion of a cylinder, fixed at the base and free to move at the crest. His calculations lead to the conclusion that a large bending moment exists at the base of every arch dam and there is the tendency of developing cracks at the heel if the dam is not anchored sufficiently to the rock foundation by means of reinforcing bars.

Graphical Method of Designing Arch Dams.—The writer has developed a simple graphical method of designing arch dams. This method is based upon the assumption that an arch dam for the purpose of design may be imagined as consisting at one time of separate radial vertical dam slices, considered as cantilevers, and at another time of horizontal arch slices. Both vertical and horizontal dam slices are preferably taken 1 ft. thick and are to be considered as free to move relatively to each other. The load is then distributed by trial on cantilever and arches in such a manner that the deflections of identical points, calculated separately for cantilever and arch system under divided load and with due consideration of shrinkage and temperature deformations, are identical.

Such a division of the water pressure between cantilever and arches is readily obtained by trial and repeated construction of the deflection lines for divided load.

First, it is assumed that the arches support all the load. The arch crowns then would be deflected along a line which may be called the arch deflection line for full load. Then it is assumed that all the water pressure be acting upon the cantilever which would be deflected along the cantilever deflection line. This line is best found graphically.

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*Abstract of a paper published by the American Society of Civil Engineers in Proceedings, August, 1920.

It is a well known principal in graphic statics that the elastic line of a beam for any load can be found graphically as the funicular polygon for the beam loaded by its moment area.† In the case of a beam with varying moment of inertia, I, the ordinates of the moment area have to be divided in each section of the beam by the respective I. The area thus obtained and applied as load area to the beam furnishes in the funicular polygon to proper scale the deflection line.

The deflection of circular arches under radial load may be obtained from the formula:

$$D = \frac{3}{16}\,\frac{L}{h}\,\Delta L \quad \ldots\ldots\ldots\ldots (1)$$

in which D = the deflection of the arch at the crown
L = the length of the arch
h = the rise of the arch
ΔL = the shortening or lengthening of the arch due to any reason, as compression, shrinkage, temperature, etc.

The shortening, ΔL, of an arch under axial pressure, as in dams, is calculated by means of the relation

$$\Delta L = \frac{f}{E}\,L$$

where
f_c = unit stress
E = modulus of elasticity.

Equation (1) may then be written in the form

$$D = \frac{3}{16}\,\frac{f}{E}\,\frac{L^2}{h} \quad \ldots\ldots\ldots\ldots (2)$$

In circular arcs with central angles between 40° and 110°, the value $\frac{L^2}{h} = 8.3\,R$ (approximately) if R is the radius of the arc. Therefore

$$D = \frac{1.56}{E}\,Rf \quad \ldots\ldots\ldots\ldots (3)$$

or because $f = \frac{PR_u}{t}$

$$D = \frac{1.56}{E}\,\frac{PRR_u}{t} \quad \ldots\ldots\ldots\ldots (4)$$

where P is the water pressure per square unit, R_u the upstream radius, and t the dam thickness at the depth investigated.

A variation in temperature of = T° produces a change in the length, L, of the arch of ΔL = cTL, where c is the coefficient of linear expansion. By equation (1) we obtain

$$DT = \frac{3}{16}\,\frac{L^2}{h}\,cT$$

and by replacing $\frac{L^2}{h}$ by 8.3 R, we have

$$DT = 1.56\,RcT \quad \ldots\ldots\ldots\ldots (5)$$

The shrinkage of the concrete during setting and hardening of the cement is about ΔL = ¼ in. per 100 ft. length. The corresponding arch deflection is readily obtained by means of formula (1).

Application of Graphical Method to Design of Wooling Dam in Australia.—An arch dam named the Wooling Dam has been built recently in Australia, for which the design was made according to more scientific principles than are involved by the use of the simple cylinder formula. The statical calculations for this dam are published in the Proceedings of the American Society of Civil Engineers, March, 1920, page 410. Those results were arrived at, as mentioned previously, by considering the dam as a portion of a monolithic cylinder, fixed at the base. It will be of interest to apply the writer's graphical method, which is based upon the assumption of combined vertical cantilever and horizontal arch action, to this same structure. It will be seen that both methods lead to practically the same results.

The dimensions of the Wooling Dam as shown on Fig. 1 (b), are as follows:

Height	[illegible] ft.
Radius of upstream face	[illegible] ft.
Crest width	2.20 ft.
Base width	4.40 ft.
Modulus of elasticity for the horizontal direction E =	[illegible] lb. per sq. in.
Modulus of elasticity for the vertical direction, considering a certain amount of vertical reinforcement E =	2,600,000 lb. per sq. in.

It is assumed for this investigation that only deformations and stresses due to water pressure shall be considered. The deformations from shrinkage of the concrete and from temperature changes shall be neglected for the present.

If all the water pressure were supported by the horizontal arches, the deflection of the crowns of these arches calculated by Equation (4) would be as given in Col. 2 of Table I.

If the cantilever had to support all the water pressure and was strong enough to do so, it would be deflected in such a way that the original dam axis would be a tangent to the deflection line at the base of the dam. At the crest the deflection would be a maximum.

As to actual load on the cantilever it is known only that it amounts to the full water pressure at the base, where no arching can occur, and diminishes in the upper elevations by those amounts which are taken by the horizontal arches. Under this partial load the cantilever tends to be deflected with a maximum at the crest. The highest arch is subject to practically no direct water pressure and therefore would not deflect if not the upper end of the cantilever exerted some pressure upon this arch on account of the tendency of the free end of the cantilever to deflect also at the crest of the dam. Therefore, an extra pressure besides direct water load is exerted against the upper arches.

By trial computation it was found that in the case of the Wooling Dam, for a distribution of the water pressure between vertical cantilever and horizontal arches, as shown on Fig. 1 (a) the cantilever under its share of the load, that is, the triangle E F K plus the reaction K G N of the upper arches, deflects at all elevation about as much as the horizontal arches under their portion of the load, which is represented by the area F K N G.

This is the criterion for the fact that the water pressure is really divided between cantilever and arches as shown in Fig. 1 (a).

Fig. 1 shows how the deflection line of the cantilever of varying moment of inertia and loaded by the pressure represented by the areas E F K and K G N can be found graphically. First, compute for sections at different elevations the moment of inertia and the bending moment due to the water pressure. Column 1 of Table I gives the elevations of the horizontal sections through the cantilever, Column (3) shows the corresponding moments of inertia, I, Column (4) gives the bending moments, M, due to the portion of the load above the sections. In figuring M it has to be considered that the load represented by the area K G N acts in opposite direction to the water pressure as K G N is the reaction of the upper arches upon the cantilever. In Columns (5) are given the values $\frac{M}{I}$. The M and $\frac{M}{I}$ curves are shown on Fig 1 (c) and also the W — areas which are to be considered as loads for the cantilever.

TABLE I.

Elev.	Arch. deflect. Total load. In.	Moment of in. I.	Bend. moment. M. Ft.-lbs.	$\frac{M}{I}$	Load area W.	Arch. deflect. Partial load In.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
33	[illegible]	[illegible]	0	[illegible]		[illegible]
24	0.23	[illegible]	6,800	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible] 1,600	[illegible]	[illegible]	[illegible]
8	0.47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0	0.54	7.10	+219,000	+30,800	172,000	0.00

In Fig. 1 (d) and 1 (e) the force and string polygons have been drawn. The curve AB inclosed by the string polygon is the deflection line of the cantilever.

The deflections of the arches under their share of the load are given in Column (7) and the corresponding deflection line A C is shown in dashes on Fig. 1 (e).

The coincidence between the cantilever and arch deflection lines A B and A C is remarkably close (within 0.01 in.) in view of the fact that the load areas have been roughly assumed as triangles. A slight modification of these load areas would result in complete coincidence of the two deflection lines, which in the dam, of course, has to occur.

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†See Mechanical Engineers' Handbook [illegible] S. Marks, First Edition, 1916, p. 412.

A comparison of Mr. Smith's results as given in the table on page [illegible] and his diagrams on page [illegible] (Transactions Am. Soc. C. E., March, 1920) with the above [illegible] of the graphical investigation shows that both methods lead to practically the same values for bending moments and deflections.

For instance, the bending moment at the base of the dam was found by Mr. Smith to be 220,900 ft. lb. per foot width and in the graphical investigation above it is 219,000 ft. lb. The maximum deflection at the crest of the dam was found by both methods to be 0.19 in. The stresses at the heel of the Wooling Dam with the reservoir full would be about 400 lb. per sq. in. tension in an unreinforced section. In case of a coincidence of low dam temperature and reservoir full, the cantilever stresses, of course, would be still higher so that the dam undoubtedly would have developed tension cracks on the upstream side if the occurring tension stresses had not been taken care of by vertical reinforcement.

From Fig. 1 (a) it is seen that the proportion of the water pressure carried by arching is less than 20 per cent of the full water pressure. This is remarkably little in view of the slender cross section of the Wooling Dam.

A further discussion of the above investigation leads to the conclusion that

1. The amount of load carried by horizontal arching is much less, and the stresses in the highest arches are much larger than the cylinder formula would lead one to believe.
2. Te cylinder formula gives correct values for the arch stresses only for a very small portion of this dam (near Elev. 27).
3. The arches near the crest have to carry more load than full water pressure.
4. The amount of load carried by the vertical cantilever is much larger than generally is assumed. This load is in most arch dams so large that there exists the tendency for very considerable tension stresses at the heel of such dams, and many among them probably have developed open cracks as indicated by deflection measurements made.

The graphical method of design shown in this article will permit the building of arch dams in which cantilever and arches act harmoniously together. Such dams will be more economical and safer than either gravity or pure arch dams.

Ditching With Dynamite in Anti-Malarial Work

A demonstration of ditching with dynamite, whereby a 20-acre mosquito breeding swamp near Miller, Ga., was converted into valuable pasture land, was carried out in February by the Central of Georgia Ry. and a representative of an explosive manufacturer. The following account of the work is given by H. N. Old, Assistant Sanitary Engineer, U. S. Public Health Service, in Public Health Notes.

The mucky soil along the proposed line of ditch was almost completely under water. Stumps of green sweet gum, black gum, and pine, up to 2½ ft. in diameter, stood about 6 to 8 ft. apart.

Owing to the presence of large roots the entire 1,500 ft. of ditch was not blown at one time, but in 10 sections, with a resulting economy in the size of charge. One stick of 50 per cent nitroglycerine dynamite was used in each hole. The holes were 24 in. deep, and in a straight line, with a spacing of 10 to 16 in., averaging 12. At times extra holes were placed to blow stumps clear of the ditch banks. A No. 3 blasting machine was used as detonator, and No. 6 electric blasting caps as primers. The immersion of some of the dynamite in water for as long as four hours between loading and firing was not apparently detrimental to the dynamite.

Within 30 minutes after the last shot there was a freely running stream in the bed. The resulting ditch averaged 7½ ft. at the top, 2½ ft. at the bottom, and 3½ ft. deep. Approximately 970 cu. yd. of material were removed, or 0.65 cu. yd. per linear foot. No hand trimming of the sides was found necessary, as is often the case.

The total cost, including 1,000 lb. of dynamite at 25.5 ct., 44 man-hours' labor at 20 ct., and $6.20 for incidentals, amounted to $270. The unit cost was 27.8 ct. per cubic yard, or 18 ct. per linear foot. It is estimated that the blowing of stumps cost 25 per cent of the total. Under similar conditions, hand ditching would be extremely difficult, and a ditch of the same size would probably cost 40 to 50 ct. per lin [illegible]

A Classification of Indiana Public Water Supplies

A recently made compilation of data for the public water supplies in Indiana shows the existence of 211 plants furnishing drinking water to a total population of over 1,600,000, or practically half the population of the state. These data have been compiled under the direction of John C. Diggs, sanitary engineer, Indiana State Board of Health, and were presented in a paper by him before the recent annual meeting of the Indiana Sanitary and Water Supply Association from which the following is taken.

Of this total of 211 plants in the state, 162 use natural ground water as a source, 6 use treated ground water, 14 use untreated surface water, and 29 use treated surface water as a source of supply. There are 35 treatment plants in all supplying water to a population of 860,000 or more than 25 per cent of the total.

Methods for classifying public water supplies have been worked out in New York State but such methods are not available for Indiana where the total annual appropriation is less than 8 per cent of that in New York. Nevertheless, it was thought that some method of classification could be worked out and a considerable amount of benefit be derived from comparisons with the meagre information available. The following factors will show the best aid in the work of classification.

1. The source of supply with reference to geologic formations from which the water is drawn and possible contamination by domestic sewage and industrial wastes.
2. The purity of the supply is gaged by chemical and bacteriological examinations.
3. The equipment of the water purification plant treating the supply.
4. The character of the personnel responsible for the operation of the water plant.

With the utilization of these factors five classes of public water supplies were made.

Class I water supplies are comprised of those plants which obtain their supply from wells adequately protected not only with reference to general water bearing formations but to local conditions as well. Such supplies must show both a satisfactory sanitary survey and chemical and bacteriological examination and must indicate a potable water.

A second group of waters placed in Class I are those produced by water purification plants which are adequately equipped to purify the raw water, which maintains suitable laboratory control and which are in charge of operators who are not only technically qualified to produce a satisfactory water but who are conscientiously disposed to exert themselves to see that such a supply is produced.

Class II water supplies are those ground water supplies usually consisting of a water of good quality but which have some unfortunately situated suction line, reservoir or well by which contamination might gain access to the city system.

Class III water supplies includes waters from improperly protected ground water sources, springs, shallow wells, etc., and purification plants not properly equipped or operated by inefficiently trained men and not including adequate laboratory control for the constant production of a safe water.

Class IV water supplies include those waters obtained from surface source, impounding reservoirs or ground waters exposed to contamination at times and from water purification plants not properly operated or not controlled by laboratories. These waters are normally of poor quality and often grossly polluted.

Class V water supplies are from supplies which are unquestionably bad through the constant contamination by sanitary sewage or other wastes.

Table I shows the plants of each class with the population. persons served and typhoid fever death rate for each city and town having a public water supply.

TABLE I—SUMMARY FOR ALL SUPPLIES.

Class	No. of plants	Pop. 1920 census	Pop. served	Ave. typhoid deaths per year	Rate
I	102	[illegible]	528,611	118	16.1
II	[illegible]	[illegible]	350,210	65.1	16.3
III	11	[illegible]	[illegible]	70.1	19.3
IV	21	[illegible]	102,200	41.5	37.0
V	1	[illegible]	10,700	8.5	35.4
Total	[illegible]	[illegible]	1,295,647	[illegible]	18.7

To eliminate to some extent the effect of rural elements which prevail in the small cities and towns a summary (Table II) has been made including only plants which supply water to communities having population of over 5,000.

TABLE II—SUPPLIES FOR CITIES OF OVER 5,000 POPULATION.

Class.	No. of plants.	Pop. 1920 census.	Pop. served.	Ave. typhoid deaths per year.	Rate.
I	13	568,373	422,250	70.4	12.4
II	16	353,288	311,650	53.1	15.0
III	14	309,522	266,500	54.6	17.7
IV	6	76,439	75,000	27.0	35.5
V				00.0	..
Total	49	1,307,622	1,078,400	205.1	15.6

Perhaps particular reference should be made to the water purification plants (Table III) for, though limited in number, these plants supply over 50 per cent of the citizens of the state supplied by public water systems and it is probable that efforts devoted toward the improvement of such supplies would be most profitable in the accomplishment of results.

TABLE III—WATER PURIFICATION PLANTS IN INDIANA.

Class.	No. of plants.	Pop. 1920 census.	Pop. served.	Ave. typhoid deaths per year.	Rate.
I	4	472,059	340,500	59.6	12.6
III	15	288,348	245,700	54.1	18.4
IV	16	102,218	100,400	36.0	35.3
Total	35	862,525	686,000	149.7	17.3

Arrangements have been made for more frequent sampling of supplies of water purification plants not controlled adequately by laboratories. The laboratories of the Water and Sewage Department of the State Board of Health are now receiving weekly samples from 20 such plants. It is felt that this plan will give the really conscientious water works superintendent an opportunity to better his city supply and at the same time keep the State Board of Health informed as to the quality of the water produced. It is hoped that arrangements can also be made for more frequent inspection which will bring about more efficient operation. Work along this line is very decidedly limited with the present organization and appropriation available for personnel. It is believed, however, that for the proper supervision of the public water supplies of the state a routine system of inspection and sampling should be outlined as follows:

Class I supplies.—A very careful inspection should be made once each year and laboratory examination at least semiannually

Class II supplies.—A survey should be made once each year and quarterly analysis of samples submitted.

Class III supplies.—Surveys of these supplies should be made quarterly and samples submitted weekly for examination.

Class IV supplies.—Surveys should be made quarterly and analyzed weekly or semi weekly.

Class V supplies.—Surveys of such supplies are useless except as a means of urging the installation of an improved system.

The writer is pleased to state that he is receiving very active co-operation of the water utilities in carrying out this plan for the improvement of the state's drinking water supply. The weekly reports from all water purification plants are, with the exception of a very few delinquents, being received in very satisfactory order and the recently introduced system of weekly samples to the State Board of Health has received the hearty support of all water purification plants. A continuation of this co-operation will greatly assist the State Board of Health in its plan to render service to the citizens of the state through the water utilities.

Cost of Wasting Water.—Mr. Henry E. Perry, superintendent of Waterworks of Dover, N. H., includes the following table in his annual report for the year 1920, to show the amount of water wasted by leaks of various sizes and for various pressures:

	Pounds pressure per sq. in. at orifice					
	50 lb.		65 lb.		85 lb.	
Diameter of orifice. In.	Cu. ft. discharged per day	Value at 23 ct. per 100 cu. ft.	Cu. ft. discharged per day	Value at 23 ct. per 100 cu. ft.	Cu. ft. discharged per day	Value at 23 ct. per 100 cu. ft.
1/16	153	$ .35	167	$ .38	198	$ .45
1/8	613	1.31	667	1.53	760	1.74
1/4	2,467	5.67	2,667	6.13	3,066	7.05
1/2	9,867	22.79	10,667	24.53	12,266	28.21
3/4	21,333	49.07	24,400	56.12	28,000	64.40
1	39,466	90.87	42,667	[illegible]	49,066	112.85

Cost of Cleaning and Painting Steel Standpipes

In a discussion of a paper "Cleaning and Painting Standpipes" presented last December before the New England Waterworks Association. Mr. H. K. Barrows, consulting engineer, Boston, Mass., gave the following information regarding the cleaning and painting of steel standpipes at Fall River and Gardner, Mass.

The tanks at Fall River were of the following dimensions:

Townsend Hill, 1 tank, 73 ft. in diameter by 37 ft. high.
Bedford Street, 2 tanks, each 65 ft. in diameter by 56 ft. high.
Haskell Hill, 1 tank, 65 ft. in diameter by 55 ft. high.

The total area of surface, including outside and inside of tanks and bottom, is about 99,300 sq. ft.

In 1915 the four tanks were cleaned by scraping, and painted inside, bottom, and outside two coats of Detroit graphite paint, the cost being:

Paint, furnished by the city, cost	$1,167.98
Labor cleaning and painting, by contract, cost	1,036.80
Total	$2,204.78

Or about $22.20 per 1,000 sq. ft. of surface.

In 1919 the four tanks were cleaned by scraping, and painted inside, bottom and outside one coat of Detroit graphite paint. The cost was:

Paint, furnished by city, at cost of	$1,320.25
Labor of cleaning and painting, day work, cost	896.00
Total	$2,216.25

Or about $22.30 per 1,000 sq. ft.

It will be noted that the cost per 1,000 sq. ft. was almost identical in 1915 and 1919, but in the former case included two coats of paint and in the latter case but one coat.

The standpipe at Gardner State Colony, Gardner, Mass., is 25 ft. diamater by 82 ft. high, with conical roof 20 ft. higher. It was cleaned by scraping, and painted in 1916, two coats inside and outside, of red-lead paint—"Government formula" —at a total cost of $458, the state purchasing the paint and contracting for labor.

The total area covered was about 15,200 sq. ft. of surface, or at the rate of about $30 per 1,000 sq. ft.

Cost of Water Main Construction at Pasadena, Calif.—The following table reprinted from the 7th annual report of the Water Department of Pasadena, for the year ending June 30, 1920, shows the cost of cast iron water main construction in that city by fiscal years since 1913:

Size.	Fiscal year ending June 30.	Ft. laid.	Labor.	Auto.	Material.	Overhead	Total.
			Costs per lin. ft				
4" Class B.	1914	15,713	$0.222	$0.012	$0.487	$0.059	$0.780
	1915	27,021	.241	.016	.430	.063	.750
	1916	12,453	.268	.024	.457	.097	.846
	1917	14,670	.267	.015	.477	.058	.817
	1918	11,020	.298	.022	.743	.107	1.170
	1919	4,890	.424	.061	.885	.155	1.525
	1920	5,576	.437	.056	.846	.171	1.510
6" Class B	1914	19,878	.257	.017	.678	.076	1.028
	1915	6,691	.356	.031	.668	.097	1.152
	1916	12,546	.296	.022	.610	.117	1.045
	1917	11,636	.252	.015	.673	.071	1.011
	1918	9,247	.333	.029	1.120	.148	1.630
	1919	3,583	.458	.071	1.157	.188	1.874
	1920	9,396	.419	.041	1.368	.223	2.051
8" Class B.	1914	11,955	.323	.018	1.042	.107	1.490
	1915	1,622	.374	.031	1.063	.135	1.603
	1916	2,748	.478	.021	.829	.171	1.499
	1917	7,323	.419	.024	1.010	.110	1.563
	1918	1,774	.390	.027	1.617	.203	2.237
	1919	2,007	.474	.068	1.679	.240	2.461
10" Class B	1914	3,541	.385	.006	1.290	.123	1.804
	1915	1,831	.422	.025	1.270	.158	1.875
	1917	749	.494	.033	1.413	.147	2.087
12" Class B	1914	8,588	.410	.024	1.600	.180	2.214
	1917	1,674	.643	.056	1.953	.195	2.847
	1919	688	.813	.082	2.986	.421	4.302
14" Class B	1916	1,200	.568	.032	1.834	.291	2.725
20" Class B	1915	3,053	.781	.061	2.732	.315	3.889
24" Class B	1917	2,266	1.870	.251	5.742	.594	8.457

Engineering Societies Affiliate with F. A. E. S.—The two latest local engineering societies to become affiliated with the Federated American Engineering Societies are the Boston Society of Civil Engineers and the Engineering Society of Milwaukee. There are a number of other societies that are either voting upon this step at the present time or have it under consideration by the executive board. It is stated to be reasonably sure that a number of other societies will become affiliated with the A. F. E. S. before July 1, at which time the opportunity of coming in as a charter member will expire.

Construction Features of New 18½-Mile Gas-Welded Pipeline of Midway Gas Co.

The Midway Gas Co. of Taft, Calif., has recently completed 23 miles of 10-in. gas trunk lines from its Elk Hill wells to connect with Bakersfield, Calif., paralleling its 6-in. line that has heretofore served the Bakersfield territory. The welded portion of this line, some 18½ miles, is of especial interest because of certain features of construction and handling employed to meet unusual conditions of terrain and climate. The line is practically a cross-country straight-away, with very few bends, traversing open prairie and marsh lands at points miles away from even the crudest pretense of a highway. The temperature variations are always considerable during the day, ranging from sharp chill in the morning and evening to scorching heat at midday, modified at times by stiff winds that rise almost to the velocity of gales. It is obvious that the welders had to contend not only with the ordinary difficulties of contraction and expansion, but with operating obstacles of an unusual nature.

Welds at 90 Turn; Welded Joints, and Welding Outfit at Work.

The work was carried on under the supervision of Mr. H. P. George, general superintendent of the Midway Co., and Mr. J. W. Farner, foreman. Mr. C. R. Haynes was the head welder on the work. Eleven welding crews, composed of welder and helper, were stationed at successive stages of the work at such intervals that it was necessary to move camp but three times to complete the line. Oxygen and acetylene tanks were moved from one joint to the next on improvised sledges drawn by mules. The pipe and other material were shipped to the nearest railroad point and trucked from there to the work, horses being used whenever marsh lands had to be crossed.

The pipe, 10-in. inside diameter, weighing 27.37 lb. per linear foot, the sections averaging 35 ft. in length, was delivered already beveled to 45° at the ends, the bevels carrying through to the base or inside circumference of the tube. The ditch for the pipe was dug under contract with a machine ditcher, and was 2 ft. in width and 3 ft. deep.

Twenty lengths of pipe were assigned as the operating unit for each welding crew. The pipe was laid on the side of the ditch and rested on skids, the crews welding the joints successively, rolling the pipe into place and turning it as the work progressed to keep the work horizontal. When a series of 20 sections was welded, the completed work was rolled on the skids until directly over the trench and lined up with the preceding series by means of chains and tongs. If it was found that the two 20-section lengths overlapped, the overlap was cut away and the abutting ends welded. In cases where there was a gap instead of an overlap, the space was filled by welding in a short section of the right length.

During the actual welding, expansion and contraction of the pipe, due to atmospheric changes, were ignored, excepting when tying in the 20th-length sections. The welding of the latter was always done in the cool of the morning to avoid any possibility of contractional ruptures. This was necessary, because, while expansion would take care of itself in effecting slight undulations in the line, without this provision for uptake, contraction tension might result in a break where, as in this case, the extreme variations in section lengths at different hours of the day sometimes amounted to as much as six or eight inches. For this reason also the pipe was lowered into the ditch only at the coldest periods of the day.*

After 3 or 4 miles of pipe had been welded, painted and lowered in the ditch, a temporary tie-in to the parallel 6 in. line was made and pressure put on to the pipeline for leaks. The end of the line was blanked off, either by welding a cap over it and later cutting it off, or by a clamp with a reinforced blind flange, the latter being done only where the pressures were comparatively low. There were but three or four defective welds that had to be repaired with the torch in the entire 18½ miles aggregating some 2,950 welds—approximately 1 to every 1,000 welds. The ratio of pinholes was less than 1 to every 100 welds, and these were easily closed with a punch.

In the entire line there was but one turn of 90°, and this was accomplished by two mitre-welds of 45° each, placed about 4 or 5 ft. apart. Near this bend was installed an 18 in expansion sleeve. There were but five expansion sleeves in the entire 18½ miles. The engineers depended primarily on the uniform temperature of the flowing gas to counteract the slight contraction and expansion that would occur in the pipe after finally in place under the ground with gas feeding through it. It has been found that the variations of temperature under operating conditions are very slight in this part of the country compared to those which the work is exposed in construction. One drip pot was installed, and was designed by the Midway engineers.

This line is for the purpose of conveying gas from the Elk Hill Wells, near Taft, to the Kern River Oil fields in the Bakersfield country. The gas leaves the wells under a pressure of about 350 lbs. to the square inch, and reaches its destination at a pressure of from 75 to 150 lbs.

It was originally intended that the Midway line should be entirely of oxy-acetylene welded construction, but shortly after work was begun it was found necessary to use about 4½ miles of second-hand pipe with screwed joints on the Elk Hill end of the line, diverting the pipe originally planned for this line to another line leading from Elk Hill toward Taft.† In the construction of the 18½ miles of welded line Linde oxygen and Prest-O-Lite acetylene were used exclusively. Definite data covering gas consumption are not at present available, as part of the 75,400 ft. of oxygen and 68,900 ft. of acetylene delivered for the line was converted to other uses. On the basis of deliveries the consumptions would average 25.56 cu. ft. of oxygen and 23.36 cu. ft. of acetylene per joint, or 9.53 cu. ft. of oxygen and 8.71 cu. ft. of acetylene per linear foot of welding—considerably higher than normal for welding ¼ in. steel; but these consumptions include oxygen and acetylene used in cutting. It is expected, however, that the corrected figures, when obtained, will be found somewhat above normal also, owing to adverse conditions of work in this particular field, where high winds retarded the welding much of the time and mosquitoes in the marshy stretches interfered with normal manipulation.

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*The expedients relating to provision for expansion and contraction in pipe lines are comparatively recent engineering developments, but are not so new as to be regarded in any sense experimental. Indeed, there is not the slighest doubt that, had similar precautions been taken, some of the earlier difficulties encountered, notably in the mid-continent field, might have been effectually removed. This is indicated by the success of welded lines in Wyoming, where even greater extremes of temperature are experienced.

†The Midway Gas Co. is now engaged in constructing a 12-in. welded gas pipe line from Taft to Los Angeles, a distance of [illegible] miles. The work on this line will be similar to that described above.

Use of Fluorescein in Tracing Water Underground

Fluorescein, a coal-tar product, stands at the top of the list of chemicals and dyes used for tracing water underground. This substance has a reddish-orange color, but when dissolved in water and diluted appears by reflected light a brilliant green. Its pre-eminence as an aid to tracing ground water lies in the fact that minute quantities can be detected by the eye without resort to chemical analysis. If material of good quality is used 1 part of fluorescein in 40,000,000 parts of water will be visible to the naked eye and 1 part in 10,000,000,000 can be detected with the aid of a long glass tube so prepared as to give full value to the green color. If a secret test is desired, do not use fluorescein, for it makes its presence known in an unmistakable manner and will prove its case to the most prejudiced observer. It is useless for waters containing free mineral acids, which render it colorless, and is unsuitable for percolation tests on peaty soils for this reason. With this exception it is available for practically universal application. Some mineral constituents of ordinary waters, particularly carbonates, will reduce the visibility of fluorescein, some of the coloring matter will be absorbed by soils through which it passes slowly, and a part tends to settle out in pools or basins, perhaps later to be washed out on agitation by a large inflow of water. These effects are small in most cases but should be considered in determining the "dose" of the indicator to be used. Generally speaking the dose should be computed to give about 1 part in 10,000,000 in the effluent if results visible to the naked eye are desired. The conditions under which the individual experiment is to be undertaken will, of course, furnish some guide to the dosage. In the March Reclamation Record, Mr. Herman Stabler, Chief Engineer, Land Classification Board, U. S. Geological Survey, gives the results of some tests made by him several years ago.

A kilogram fluorescein was placed in a stream of 1.2 second-feet flowing into a sink hole in limestone. It was next seen 24 hours later at the outlet of an underground stream flowing 2.5 second-feet and at a point 12,000 ft. distant. This stream was turbid and the time required for the flow was so great that passage through large pools was indicated. However, the effluent stream showed a maximum of 0.15 parts per million of fluorescein and the flow continued visible to the naked eye for 60 hours. Apparently 12.5 acre-feet of water were colored with an average intensity of 1 part in 15 or 16 million, and a maximum intensity of more than 1 part in 7 million. With these small quantities and the rather unfavorable conditions—turbid water, passage through pools or basins, and high carbonate content—there was no question whatever of the successful tracing of the flow.

A second experiment from another sink hole leading to the same outlet stream was even more noteworthy. In this case the dye was placed in a stream flowing only 0.1 second-foot at a point 4,000 ft. from the outlet. The effluent again showed green for about 60 hours, the average intensity being about 1 part in 34 million. The maximum intensity was greater than before, however, and a comparatively clear surface stream of 3.3 second-feet discharge that received the flow was colored green to the naked eye for several miles and gave rise to considerable comment by the residents of the region.

A third experiment was made with 2 ounces of fluorescein placed in the sink (sandy bed) of a stream flowing 0.1 second-foot. The color appeared 1½ hours later in what was supposed to be a spring free from surface contamination. The spring and sink were only 150 yd. apart. The color disappeared from the spring in 30 hours but was visible 3 days later in pools of the branch into which it discharged. This indicates the tendency to settle out in pools.

A fourth experiment of the series involved placing 1.5 lb. of fluorescein in a sink hole in limestone in the bed of a stream flowing half a second-foot. This resulted in coloring a 2 second-foot spring a bright green for two days, beginning 25 hours later. The distance between sink hole and spring was 2,500 ft. and the difference in elevation 175 to 200 ft. In this case 4 acre-feet of water was colored with an average intensity of about one part in 7 million. The water was clear and the brilliant green coloring of what was normally a beautiful blue limestone "spring" was a most satisfying proof of the connection that was suspected by some and vigorously denied by others.

In all these experiments an attempt was made to make the dose large enough to give results, for no damage from the excess could result and undeniable proof of underground connection was desired. Probably half of the material could have been saved, but the conditions to be encountered were unknown. The slow and varying velocities of the underground streams, as measured by surface distances, 500 ft. per hour, 200 ft. per hour, 300 ft. per hour, and 100 ft. per hour, were unsuspected.

If simple tracing of an underground connection is desired, as in the foregoing cases, the proper method is to dissolve the calculated dose of fluorescein in a small quantity of water and place it in a single charge at the plant where water disappears underground. Then watch all possible springs or wells for results, collecting samples and examining them in a long tube of colorless glass (long to get the color of a great depth of water, and colorless to avoid confusion with the anticipated green) at reasonably frequent intervals. Seepage from a canal can be traced by placing fluorescein in pits or borings alongside or in the bed of the canal, or, if the canal is closed down, by impregnating a minimum amount of stagnant water in the suspected part of the canal prism. In such cases the rate of underground flow is likely to be only a few feet per day, and there may be a wide diffusion of the waters. A calculated overdose of fluorescein should therefore generally be used, and observations should be continued long enough to make sure of a result.

The Cost of a Typhoid Fever Epidemic

The importance of a safe city water supply is brought to our attention with a fresh emphasis by reason of a severe typhoid fever epidemic that broke out in Salem, Ohio, in October. More than 850 cases of typhoid fever and approximately 50 consequential deaths were reported during the course of the epidemic. The Ohio State Department of Public Health attributes the cause of the outbreak to "Sewage entering the water supply system through leaks in a tile pipe line" and estimates the cost of the epidemic at $450,000 on the following basis:

State appropriation	$ 5,000
Red Cross appropriation	50,000
Municipal appropriation	15,000
Private expenditure for medical service and drugs (850 cases at $50 each)	42,500
Private expenditure for nursing service (200 cases at $100)	20,000
Loss of time by wage earners (one-third of cases, six weeks each at $5 per day)	60,000
Funeral expenses (approximately 50 deaths at $150)	7,500
Value of lives lost (approximately 50 at $4,000 each)	200,000
Business losses (due to lowered earning power of workers and to avoidance of city by out-of-town persons)	50,000
Estimated total cost	$450,000

The tile pipe line cost $1,500 less than an iron pipe line would have cost. About $1,000 each year would have covered the cost of bacteriological supervision over the water. A total saving of $2,500 appears against the epidemic cost of $450,000.

Examples of cities in Illinois that have paid the same kind of a price for maintaining defective water supply systems are not wanting. Only a few months ago the city of Bloomington experienced a sharp outbreak of typhoid fever and diarrhea due to a cross-connection between the city water supply and an impure industrial supply. The actual money cost of this epidemic ran into thousands of dollars. Many cities and towns in this state still maintain cross-connections and other dangerous defects in the public water supply system regardless of the frightful experiences of other communities.

We ask again "will cities ever learn from the experiences of other cities how to protect their public water supply?" It seems that such terrible experiences as those of Bloomington, Illinois, and Salem, Ohio, would be sufficient to awaken the officials in the most backward community in the country to the dangers that lurk behind cross-connections and other dangerous defects in public water supply systems.—Editorial in Illinois Health News, the official monthly bulletin of the State Department of Public Health.

Public Water Supplies in Massachusetts.—Of the 354 cities and towns in Massachusetts, 215 are provided with public water supplies. The total population of these places is about 96 per cent of the population of the state. Many of the remaining towns are very small, with no considerable aggregation of population at any point, but at the end of 1919 there were still 21 towns, which had by the census of 1915 a population in excess of 2,000, in which the domestic water supply of the inhabitants derived wholly from private wells.

The Basis for Extension of Water Mains

The extension of water main [illegible] problem particularly when it comes to determining the income which should be received from the extension. In the past few years the problem has been still further complicated by reason of high and uncertain prices.

As a basis for determining the proper income, Dow R. Gwinn, president and manager, The Terre Haute Water Works Co., Terre Haute, Ind., prepared a paper which was presented before the recent annual meeting of the Indiana Sanitary and Water Supply Association. The following notes are taken from his paper.

Previous to the war cast iron pipe was delivered f. o. b. Terre Haute for $22 per ton; in October, 1920, the price was $77.60. Fire hydrants, valves, special castings and valve boxes are also very much higher in price. Common labor costs twice as much as formerly.

It costs a little over $1.80 per foot to furnish and lay 6-in. Class B cast iron pipe at present price—$64 per ton. On this basis the cost of an extension for a block of say 365 ft., including the fire hydrant, valves, valve boxes and 6-in. tee, is $829. If it is necessary to cut into a main and insert a special for a connection, the cost would be greater.

In estimating cost of pipe laying, the cost of connecting with existing mains is sometimes overlooked. It is expensive to shut off a main, cut a piece out of it, pump out the water that is in the main, insert a special, cut a piece of pipe to close the gap, put on a sleeve, and make four lead joints. It sometimes happens in Terre Haute that the water from the pipe softens the earth so that there is a caving of the banks. A number of valve stems have been broken while the workmen were trying to shut the water off so that the cut could be made. However, for present purposes, we will estimate a block of 6 in. pipe at $829.

Assuming that the extension is needed and that the water department or company can finance the improvement, the next question would be: What additional income should the department or company receive? In the writer's opinion, the income should be the same regardless of whether the water works belong to a municipality or company. A municipally owned plant should be conducted on business principles and should charge for fire hydrants and they should be paid for out of the general fund.

The Indiana Public Service Commission allows water companies a rate of return of 8 per cent and 1 per cent for depreciation. Assuming that the cost of operation and taxes are 10 per cent of the valuation, the charge against an extension of a block of 6-in. pipe with one fire hydrant should be 19 per cent of $829, or $157 per annum. The extension should pay its proportionate cost or rate of return on the main plant. Something should be added for return on these items.

In many cases it would be necessary to put in 8-in. or larger pipe. If 8-in., the cost for a block, including hydrant, valves, etc., would be $1,000. In that case, the income should be $190 per annum. If 12-in. pipe, it would be considerably higher and someone must pay on this investment and also sufficient to cover proportionate cost of operation. How is the $157 or $190 to be paid? It should be paid by those who are benefited. There are two kinds of extensions, one where there are houses where water supply is needed at once, and another in virgin territory which a real estate owner wants to develop and sell off in lots.

First, let us consider an extension inside the city where some houses have been built. On an average city block of 365 ft., after deducting the street, there would be say 14 42-ft. lots. It would seem only fair and reasonable that there should be, say, six houses on the 14 lots; that each of those should guarantee a $1.50 minimum monthly rate (about 5 ct. per day) for a period of five years. Then if the city would pay $50 a year for the fire hydrant, there would be an annual income of $158.

If the extension required 8-in. pipe (60 per cent of the mains in Terre Haute are 8-in. and larger), then the six prospective consumers should guarantee $1.75 minimum per month and the hydrant rental should be $60 per annum. This would mean an income of $186 per annum, if all the consumers kept up their payments.

Second, where extensions are desired for the development of real estate so that lots may be sold, such extensions are for the benefit of the landowner and he should pay the cost, and be reimbursed by the water department or company when the income from the water consumers and hydrant rental on such extensions is equal to the rate of return (on the original cost) allowed by the Indiana Public Service Commission plus depreciation and the proportionate cost of operation and taxes.

The form of contract with the land company provides that the landowner will be reimbursed for the cost of the extension, but without interest. The income from the consumers and also any hydrant rental belongs to the department or company for service rendered. The plan enables the land owner to improve his property and make it attractive to prospective buyers at the cost of the main pipes, meters and service pipes to curb line. He is not required to make an investment for pumps, boilers and filters. He does not have the responsibility of operating a water plant; he gets the benefit of the same prices for material that the department or company enjoys.

The cost of the water pipes, etc., are a part of the development, like sidewalks, grading and trees, except that if good judgment has been used in selecting the land and the lots are sold at profitable prices in a reasonable period, the owner may be reimbursed for that portion of his investment for water mains. Incidentally, the cost of all improvements are added to the price of lots when they are sold.

In conclusion, it should be stated that a community can not grow and prosper unless its utilities are prosperous; their interests are closely related, and what hurts one ultimately injures both. To be prosperous, a utility must have adequate rates which will produce sufficient earnings to make its securities attractive to the investor.

Building Operations in March Show 65 Per Cent Increase.—The figures for building activity in March, as published by the F. W. Dodge Co., indicate widespread progress toward resumption of normal activity. Contracts awarded during March in the 25 Northeastern States amounted to $164,194,000, an increase of 63 per cent over the February figure. The increase is largely due to a greatly increased number of small projects. The total number of contracts awarded in March was 78 per cent greater than in the preceding month. A comparison of this year's activity with that of last year is not to the point. At this time last year building activity was approaching the crest of a wave; now it is emerging from the trough. The conditions of this year are more nearly like those of 1919. Contracts awarded during the first quarter of this year have numbered 12,180 and have amounted to $376,631,000. During the first quarter of 1919, contracts numbered 10,724, amounting to $274,562,000. Among the contracts let in Mach, 1921, residential projects took the lead, amounting to $60,693,000, or 37 per cent of the total. Public works and utilities amounted to $34,068,000, or 21 per cent of the total; business buildings, $22,776,000, or 14 per cent of the total; educational buildings, $19,030,000, or 11 per cent of the total; industrial buildings, $10,640,000, or 7 per cent of the total. Contemplated new projects were reported in March to the number of 10,184, at an estimated cost of $398,071,000. The very considerable increase in contemplated new work is largely made up of small projects.

Killing Pocket Gophers on Irrigation Projects.—Pocket gophers burrowing in the ditch banks and adjacent bottom lands below the Elephant Butte Dam in Dona Ana County, N. Mex., cause seepage damage estimated at $60,000 a year. Irrigation farmers last year enlisted the directive assistance of the United States Department of Agriculture Biological Survey, and a project of extermination was undertaken in September. Both traps and poisoned baits were used. One method was for a workman to patrol the banks of the main ditches, setting a string of 50 traps at short intervals. On his return he would find pocket gophers in two-thirds of them. In doing this advantage was taken of the rodents' dislike for warmth and light. Runways were found by means of a prod and a hole was broken under which the trap was set. The gopher would hasten to the spot to repair the break and find himself in the trap. Cubes of strychnine-mixed bait were dropped into similar holes on level ground. A survey taken early this spring by a roden inspector of the Biological Survey indicated that 95 per cent of the pocket gophers had been exterminated, practically eliminating the $60,000 annual damage. The total cost to the farmers was about $3,500.

The Depletion of Ground-Water Supplies*

By ROBERT E. HORTON,
Consulting Hydraulic Engineer, Voorheesville, N. Y.

Time Required for a Well to Reach Equilibrium with Constant Draught.—It not frequently occurs where wells are used for public water supply or for irrigation that there is a progressive depression of the water table, sometimes continuing for years. It is evident that a new well might derive an initially large but ever decreasing supply from connate water, even with no infiltration. In general, with constant draught and infiltration, the well will reach equilibrium when:

Total inflow + Storage draught = Total draught.

For a horizontal or nearly horizontal water table, the inflow takes place by infiltration over the cone of depression created by the well. If the slope of the cone influence is known, then the radius and volume of the cone for any depth of depletion, and the area over which infiltration supplies the well at any moment can be determined. Miller-Brownlie† has attacked this problem at a different angle from other investigators. Instead of assuming, as is often done, a constant maximum radius of the cone of influence, he assumes a minimum constant slope of the water table within the limits of the cone, which slope he assumes will be quickly reached after pumping begins and will remain constant as depression advances. He says:

> Observations made during the past few years of the subsoils of the Punjab have shown that the slopes necessary to cause water motion have varied from 1 in 260 in moderately coarse sand to 1 in 175 for fairly fine sand. In gradients flatter than this in each type of sand there is no apparent motion. Capillary attraction interferes with the true flow, and investigation into the forward motion becomes greatly involved. Observations indicate that any lateral or forward motion of water, where the hydraulic gradients are slightly less than those mentioned, is so slow that for practical purposes it may be neglected, the actual velocity probably not exceeding a few inches per day.

In effect this amounts to the assumption that there is a minimum angle of friction for ground water similar to the angle of friction for solids. If the slope of the water table is at less than this minimum angle, motion, or at least appreciable motion, in supplying a well, will not occur.

Miller-Brownlie applies this principle to the determination of the progressive depletion of wells, making computations by yearly intervals.

The same results may be obtained by the use of a general formula derived as follows: Referring to Fig. 1, let

r = radius of cone of influence at time t in years;
m = assumed minimum slope for the given soil;
h = the true or cone depression of the water table at the well, due to the slope of the water table.

This is designated by Miller-Brownlie as the "vertex head." This does not include the abrupt depression h_t due to entrance resistance immediately around the well, which may amount to a few feet. This is designated by Miller-Brownlie as the "trumpet head," from the resemblance of the form of depression at the well to the mouth of a trumpet.

$h = mr$ and
$H = h + h_t$ = total depression.
P = available porosity of the medium.
I = infiltration depth inches on surface per year.
F = infiltration rate at time t, cubic feet per year.
Q = rate of draught or pumpage, cubic feet per year.
q_2 = rate of draught or pumpage, millions of gallons per 24 hrs.
S = total storage depletion in cubic feet at time t.

Then in units of cubic feet per year:

$$S = \frac{\pi P}{3} m^2 r \quad \quad (1)$$

$$F = \frac{I}{12} \pi r^2 \quad \quad (2)$$

The limit of the cone of influence for constant pumping will be reached when F = Q, or when

$$r = \sqrt{\frac{12\,Q}{\pi I}} \text{ or } h_c = m\sqrt{\frac{12\,Q}{\pi I}} \quad \quad (3)$$

To determine the time when this limit will be reached, or when any less depletion will be reached, it is necessary to solve the storage equation

Inflow = Outflow + Gain or — Loss of storage.....(4)

For an increment of time dt, during depletion, the loss of storage is the difference of volume of porosity in two cones of altitudes h and h + dh respectively, and side slopes m. This is very approximately equal to the convex surface of a cone of base radius r and altitude h, or πr^2 sec. A multiplied by PcosAdh or

$$dS = P\pi r^2 dh \quad \quad (5)$$

Substituting (2) and (5) in (4) for time dt,

$$\frac{I}{12}\pi r^2 dt = Q dt - P\pi r^2 dh \quad \quad (6)$$

But r = h/m

$$\text{Let } A = \frac{I\pi}{12\,m^2} \quad B = \frac{P\pi}{m} \quad \quad (7)$$

$$Ah^2 dt = Q dt - Bh^2 dh \quad \quad (8)$$

Divide by dt and transpose —

$$dt = -\frac{Bh^2}{Q - Ah^2} dh \quad \quad (9)$$

This can be integrated by known forms, giving

$$t = 2.30\frac{BQ}{2A\sqrt{AQ}} \log_{10}\frac{\sqrt{Q} + h\sqrt{A}}{\sqrt{Q} - h\sqrt{A}} - \frac{Bh}{A} \quad \quad (10)$$

Miller-Brownlie's treatment of this subject, and the author's formula based thereon, differ from the usual mode of treatment in that it is assumed that the supply of the well is ultimately derived entirely from infiltration over the area covered by the cone of influence, whereas in the usual method of treatment heretofore it is assumed that the well is supplied by water flowing into the cone of influence around the periphery of this cone, and infiltration on the area of influence is neglected. The usual formulas give the yield of the well in terms of the depth of depression of the water table. The author's formula not only gives the ultimate depth of depression which is approached as a limit as pumping continues, but it will also give the depression of the water table at the well at any chosen time interval after pumping begins.

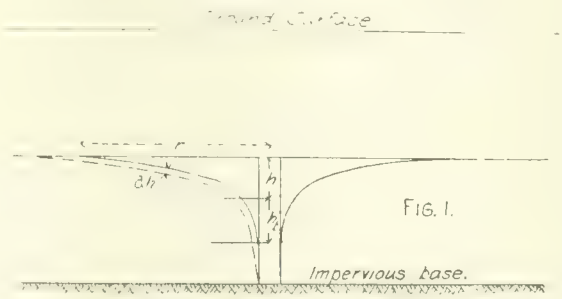

FIG. 1.

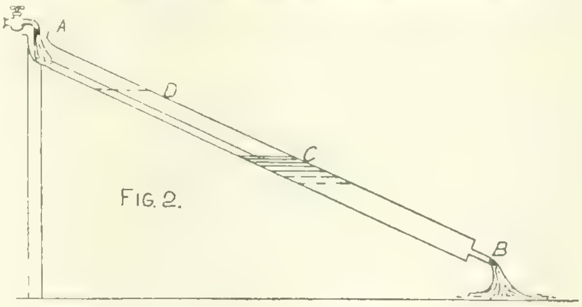

FIG. 2.

Fig. 1—Conditions Adjacent to a Pumped Well. Fig. 2—Shrinkage of Artesian Area With Increased Draught of Water.

Inspection of the formula shows that the value of t becomes infinity when the denominator of the logarithmic term becomes zero, that is when

$$\sqrt{Q} = h\sqrt{A} \quad \quad (11)$$

or when

$$h = \sqrt{\frac{Q}{A}} \quad \quad (12)$$

Illustration of Method by Miller-Brownlie Formula.—This is the limit of the vertex head, and this formula gives the same result as that obtained by the solution of equation (3).

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*From the March Journal of the American Waterworks Association.

†"Subsoil Water in Relation to Tube Wells for Irrigation," Engineering and Contracting, March 31, 1920, page 355.

In the example given herewith, the maximum depression approaches 33.68 ft. Table I contains the results of a solution of equation (10) for a well used as an example to illustrate the method by Miller-Brownlie. The results agree substantially with those obtained by Miller-Brownlie by solution for successive finite increments of h.

TABLE I—CALCULATION OF DEPLETION OF GROUND WATER IN A WELL FOR Q = [illegible] PER YEAR.

M = 0.00555 AND F = [illegible], WHERE

$$t = 14.54 \text{ Log}_e \frac{9592 + 285h}{9592 - 285h} - 0.375h$$

h (1)	285h (2)	9592 + 285h (3)	9592 − 285h (4)	Col. (3) ÷ col. (4) (5)	Log. col. (5) (6)	14.54 × col. (6) (7)	0.375h (8)	t = col. (7) — col. (8). years (9)
5	1,425	11,017	8,167	1.348	0.12969	1.88	1.87	0.01
10	2,850	12,442	6,742	1.845	0.26600	3.87	3.75	0.35
15	4,275	13,867	5,317	2.608	0.41631	6.05	5.62	0.41
20	5,700	15,292	3,892	3.928	0.59417	8.61	7.50	1.11
25	7,125	16,717	2,467	6.78	0.83123	12.04	9.38	2.66
28	7,980	17,572	1,612	10.89	1.03703	15.08	10.50	4.58
30	8,550	18,142	1,042	17.42	1.24080	17.98	11.25	6.73
31	8,835	18,427	757	24.35	1.38650	20.16	11.62	8.54
32	9,120	18,712	472	39.65	1.59824	23.20	12.00	11.20
33	9,405	18,997	187	101.50	2.00647	29.08	12.38	16.70
33.5	9,547.5	19,140	45.5	421.00	2.62128	38.01	12.56	25.48

Let Q = [illegible] = 92,016,000 cu. ft. per year.

$I = \frac{1}{12}$, P = 0.8, F = 0.30, $m = \frac{1}{180} = 0.00555$

$\frac{1}{m} = 180$ [illegible] $32{,}400$

m [illegible]

$A = 0.8 \times \pi \times 32{,}400 = 81{,}430$

$B = 0.3 \times \pi \times 32{,}400 = 30{,}536$

$B/A = 0.3/0.8 = 0.375$

$\sqrt{Q} = 9591.7.$

$\sqrt{A} = 285$

$\sqrt{AQ} = 2{,}733{,}720.$

$2\sqrt{AQ} = 5{,}467{,}440.$

$Q/2\sqrt{AQ} = 16.83.$

$$t = 14.54 \text{ Log}_e \frac{9592 + 285h}{9592 - 285h} - 0.375h.$$

In this example a depletion of nearly 20 ft. occurs in the first year because the infiltration area is naturally small, and the supply is at first drawn mainly from ground-water storage. After the first few years the infiltration rate approaches the draught rate, and the depletion approaches the limit 33.68 feet more and more gradually as time goes on.

Determination of Maximum Yield.—If a well is put down in the surface ground water horizon, and this is underlain by an impermeable stratum, then the maximum draught from the well will be that for which the depression of the vertex head plus the trumpet head equals the depth of the ground water. Until this depression is attained a greater rate of pumping can be carried on. Formula (3) is therefore adapted to the determination of the maximum yield which can be permanently derived from a given well. For this purpose it takes the form

$$Q = \frac{\pi I}{12}\left(\frac{H_g - h_t}{m}\right)^2 \qquad \text{. . (13)}$$

in which H_g is the total depth of ground water. The trumpet head h_t is the only factor that varies with the diameter of the well. For a given draught rate, this varies about inversely as the circumference of the bore.

For example, with the other factors the same as before, $H_g = 20$ ft., and $h_t = 5$ ft., Q = 18,300,000 cu. ft. per year, or 33,400 gal. per day, a comparatively small yield, because of the limited area of infiltration tributary to the well. This shows the importance of a deep ground water bed as affecting the yield of a well in the surface zone of ground water. The formula has limitations in its applicability to a well penetrating a definite vein of free flowing ground water, in which case m is practically zero.

If a well is put down into a ground-water horizon in a deep permeable stream, the surface of the water table being nearly flat, but there being a gradual flow or drift in one direction, then it is evident that water will flow into the cone of depression from one side, and a nearly equal amount will flow out from the opposite side. The effect will be to distort the form of the area of depression making it eccentric to the well, with the shorter radius on the upstream and longer on the downstream side, but without much influence on the yield of the well. In fact, it is evident that if a series of uniformly spaced wells was put down and pumped at such rates that their cones of influence were tangential circles, then the supply to each well would be derived necessarily from infiltration over the area of influence.

The Miller-Brownlie formula applies directly to this case, whereas the ordinary formulas are inconsistent in that they assume in such a case that the well is supplied from the area between the tangential cones of influence, in spite of the fact that at the points where the circles of influence are tangential there is no infiltration whatever.

Depletion of Artesian Basins.—The matter here considered is entirely distinct from the reduction in flow of artesian wells by mutual interference of wells spaced too closely. An artesian basin may have a capacity so great that the pressure over the basin as a whole is not materially affected by a limited number of wells, but if two or more wells are spaced too closely, cones of pressure reduction adjacent to the wells will overlap, and the supply available from each well will be reduced.

On the other hand, a large number of wells distributed over a basin, and so spaced as to avoid mutual interference, may gradually deplete the artesian supply to such an extent that some of the wells, usually those at higher elevations or nearest the intake beds, will cease to flow. This condition has developed notably in some of the great artesian basins of Australia, and in Southern California.

It is convenient here to consider artesian basins of four kinds:

(1) Inclined basins with ocean outlets.

(2) Inclined or saucer-shaped basins with outlets through artesian springs only.

(3) Inclined or saucer-shaped basins without natural outlets.

(4) Buried or imbedded artesian basins.

The various artesian horizons adjoining the Gulf of Mexico in Southern Texas afford illustrations of the first type. Here, before wells were bored, a balance was maintained between the inflow to the basin through the intake beds, and the outflow where the beds are exposed beneath the sea level, by slight fluctuations in the volume of storage in each artesian horizon.

The conditions are illustrated by Fig. 2. The pipe AB corresponds to the water-bearing beds. As long as the outlet at B remains unchanged in size, the water level at D will fluctuate only to such an extent as is required to satisfy the storage equation

$$\text{Inflow} = \text{Outflow} \begin{pmatrix} + \text{Gain or} \\ - \text{Loss of Storage.} \end{pmatrix}$$

If in addition to an outlet at B, wells are put down along the line DB, affording additional outlets, then a less head will be required to discharge a quantity of water equal to the inflow at A and the ground-water horizon adjacent to the intake will fall to some level lower than D. As the flow of wells is increased between A and D, the pipe will not be filled with water and a well put down in this region will have no pressure in excess of that of the atmosphere. As the number of wells between D and A is increased, the static water level in the ground-water horizon on the intake side of the basin will further recede, the artesian pressure over the entire basin will be decreased, and if the number of outlets is sufficient, the artesian horizon will fall to some level C, and wells located between D and C will cease to flow, while these between C and B will continue to flow but under greatly reduced heads.

It is evident from these considerations that excessive draught from an artesian basin in general has the effect of reducing the artesian area on the side of the basin located nearest the intake beds. Precisely this result has followed excessive pumping from the artesian basin of Los Angeles County, Cal., where the intake beds lie to the northeast. In such cases the depletion of the artesian horizon and the reduction in the artesian area may be very gradual, if the basin is large, owing to the fact that during the period of depletion to a given level the available supply equals the simultaneous inflow plus the water previously stored in the water-bearing beds of the depleted area.

Reverting to Fig. 2, the available supply during depletion from level D to level C equals the inflow plus the initial storage in the prism DC, when saturated, minus the limited volume of water remaining in this prism after depletion of the water horizon to the level C.

The lower peninsula of Michigan apparently affords examples of large saucer-shaped artesian basins, in which the natural outflow was through artesian springs in the river valleys. The conditions governing the depletion of artesian areas without ocean outlets are the same as for inclined basins with ocean outlets, but the effect may be somewhat more complicated.

Sealed artesian basins of type 3, for which there are no natural outlets, the water remaining stagnant until the wells are put down, are probably rare in occurrence and usually of limited extent. Such a basin having no natural outlets may, if tapped by a bore, yield at first a large supply of water, but if, as is likely to be the case, the storage in the water-bearing beds and the intake area are limited, the available supply and the artesian head may decrease rapidly. It is possible that such an artesian bed may have been saturated with salt or connate water, and the effect of an artesian bore in such a basin may be the production of a well from which the salt or other mineral constituents of the water will gradually decrease as the original stagnant water is replaced by fresh water taken in through the intake beds.

Obviously, an artesian horizon without natural outlets, but with an intake bed, would fill up to the surface level at the intake beds. The intake beds in such a case would probably be permanently or intermittently moist or swampy The draught of water from the basin through artesian bores would have a tendency to drain the swampy intake area. There is some evidence that a few instances of this kind may have occurred in the case of shallow artesian horizons underlying the deposits of glacial drift in Southern Michigan.

It is of course possible that beds of porous material laid down in the bottoms of shallow fresh-water lakes, and around their margins, may be covered with impervious materials while saturated, in such a manner as to be completely sealed, leaving no outlet nor permeable intake area. An inclined bed of porous material bearing connate water, but without an intake area, would, if tapped by a bore under suitable conditions, afford a yield of artesian water which might be fresh but would probably be highly mineralized. Theoretically, at least, air must enter the bed before water can flow out, unless the bore reaches the ground surface at a level more than 34 ft. below the uppermost water surface level in the water-bearing bed. However, more or less air and other gases are always contained in the pores of even the most impervious rocks, and air will flow through openings which water will not enter, so that a bed of connate water such as described, and which represents virtually a fossil lake, may yield at first a liberal supply of artesian water. Having no intake supply the flow from the well will rapidly decrease and soon cease, and the supply cannot be replenished.

In the case of artesian basins of the first three types mentioned, having intake beds, the original conditions can be restored after depletion by a cessation of draught from the wells sufficient to restore natural equilibrium by filling up the water-bearing beds to their initial level. It is important to note that repletion occurs only when the inflow exceeds the draught. A reduction of the draught rate to the equivalent of the inflow rate after the artesian horizon is depleted affords no remedy. An equal quantity of water can be drawn from the same basin continuously under greater heads, over a larger area, and in larger volumes per individual well, if the original conditions of equilibrium are restored.

For example, the artesian basins of Los Angeles County, Cal., may be capable of yielding permanently 200 cu. ft. per second or more. Under present conditions, as a result of excessive draught, this volume of water can only be obtained at great cost by pumping from excessive depths. By permitting a restoration of the original storage in the artesian horizon, the majority of the wells would again flow at the surface, pumping could be dispensed with, and a great economic saving would result.

In connection with the use of artesian wells for public water supply, a similar condition sometimes pertains. A proper mode of procedure in such cases is to obtain an auxiliary source of supply adequate for present uses, allowing the artesian supply to rest for a period of years until restoration of the artesian horizon is accomplished. From then on, the artesian supply may be used as an auxiliary to meet increased water requirements, and so long as the draught does not exceed the available inflow to the intake area, the cost of procuring the water will be a minimum.

It is particularly to be noted that in general an artesian supply differs from a ground-water supply derived from shallow wells in the surficial ground-water zone, in that the intake area of artesian supply is fixed by natural conditions and does not vary with the draught from the ground-water horizon, whereas in the case of shallow wells in the surface zone, the infiltration area generally increases as the depth of depletion of the ground-water horizon increases by pumping. As a result, artesian supplies are likely to be lowered by excessive pumping more rapidly than surface ground-water supplies.

The continent of Australia consists of an arid interior basin, surrounded by mountain ridges. There are several great artesian horizons within this basin, the largest, at least, of which is of the interior type with artesian spring outlets. The extent to which agriculture can be carried on in Australia is determined by the water supply. A given number of sheep can be raised per miner's inch of available water. The yield of artesian bores in the Australian basins has gradually decreased since the utilization of these waters began.

The decrease in the yield of artesian bores may be due to various causes other than excessive draught.

(1) These causes include caving in of the bottom of the well, thus plugging the outflow pipe.

(2) Partial closing of the pores in the water-bearing bed, closely adjacent to the well, by silt.

(3) Leakage from the well into overlying non-artesian strata as a result of corrosion of the well casing.

While these conditions are all experienced in Australia, yet accurate measurements of the yield of hundreds of bores indicate that the average yield per well is decreasing at a rate of nearly 8 per cent per annum.

In the Los Angeles County artesian basin the area in which wells flow has decreased from an original extent of 150 square miles, to 105 square miles in 1904. In the Downey district there were more than 3,000 wells in 1904, and in the adjacent Las Balsas District 300 wells. At that time a supply of 265 cu. ft. per second was derived from pumped wells, and an estimated supply of 500 cu. ft. per second was derived from flowing wells, making a total draught from the artesian horizon of some 750 cu. ft. per second.

In conclusion, experience shows extensive depletion of ground-water supplies in some instances over large areas. The analysis of well problems by Miller-Brownlie's method leads to results concordant with experience in such cases. This method depends on the assumption that the ground-water slope in the cone of influence approaches a minimum limit as depletion progresses, and that the supply to the well is derived from storage within this ultimate region of influence plus infiltration over the depleted area.

This differs from ordinary well-yield formulas in which, while it is assumed that there is a maximum limit of the cone of influence, the assumed limit is usually smaller than that used in the Miller-Brownlie method. In ordinary formulas, infiltration over the cone of influence is usually neglected, and it is assumed that the supply is derived from ground-water flow from outside the cone of influence. Both methods of analysis are based on convenient working hypotheses. Neither one completely replaces the other, but each has its special applications.

Cost of Surveys for Irrigation Project.—The cost of surveys on the Minidoka North Side Pumping Unit, Idaho, are summarized as follows by Mr. Ferd Schlapkohl, Assistant Engineer, U. S. Reclamation Service, in the March Reclamation Record:

121,248	acres of detail topography at $0.246 per acre.
476	miles of level control at $13.09 per mile.
606	miles of subdivision at $15.60 per mile.
80,000	acres reconnaissance topography at $0.13 per acre.

The above cost on subdivision and topography does not cover these features to completion. In the case of topography the cost given covers the field work, inking in of topographic sheets, reducing scale from 1 in. = 400 ft. to 1 in. = 1,000 ft., inking in and tracing of the reduced sheets, and tracing of about one-third of the 1 in. = 400-ft. sheets; there remain about two-thirds of the sheets to be traced, which will not affect the above cost to any great extent.

Results of Cleaning Water Mains.—The Committee on Water Service of the American Railway Engineering Association in its report submitted last month at the annual convention of the association cited the following cases of the results obtained from cleaning water mains:

8-in. main, 11,575 ft. long, cleaned September, 1909. Pressure required before cleaning 110 lb. for 400 gal. per minute. After cleaning 49 lb. was required to deliver 450 gal.

6-in. main 7,200 ft. long. Former pressure at pumps 84 lb. New pressure 65 lb. Former capacity 180 gal. per minute, new capacity 220 gal. per minute.

Union College to Have Course in Administrative Engineering

The Civil Engineering Department of Union College, Schenectady, N. Y., has revised its curricula and now offers two 4-year courses of study: One a technical course, and the other an administrative engineering course. The studies of the freshman and sophomore years in the technical and administrative courses are identical, and are also exactly like those of the freshman and sophomore years in the electrical engineering course. It is only in the junior and senior years that the various engineering courses differ. The new administrative course is planned to give general and scientific training in such subjects as mathematics, physics, chemistry, French, Spanish or German, and to furnish a broad engineering foundation combined with training in business administration. Although the course is especially planned to train young men for administrative positions in manufacturing, the great value of applied science is realized, and training in the most important engineering subjects, such as structural engineering, electrical engineering, and machine design, is included in the course. That the course is well-balanced is shown by the fact that studies in science comprise 26 per cent of the total four years' instruction; engineering 39 per cent; business administrative 10 per cent; cultural studies 25 per cent.

Cost of Living

The National Industrial Conference Board's estimate of changes in the cost of living to March 1, 1921, shows that the cost of living among wage-earners in the United States has fallen 4.4 per cent during February, and was 68.6 per cent higher on March 1, 1921, than it was in July, 1914, as against 76.3 per cent higher than the 1914 base on Feb. 1, 1921. There was a drop of 35.9 points or 17.6 per cent between July, 1920, the highest point reached since 1914, and March 1, 1921.

It should be noted, however, states The Iron Age, from which this article is taken, that the percentage of decrease from a higher to a lower base is always less than the percentage of increase from the same lower base to the same higher, although the change in index points is the same in both cases. Thus, while a drop of 35.9 points from an index of 204.5 to an index of 168.6 represents a decrease of 17.6 per cent, a rise of 35.9 points from 168.8 to 204.5 represents an increase of 21.3 per cent. In the same way the drop of 4.4 per cent from February to March represents corresponding increase of 4.6 per cent.

Changes in the average cost of living in the United States between July, 1914, and March 1, 1921, are shown in the tabulation below:

	Relative importance in family budget.	Percentages of increase in the cost of living above average prices in July, 1914, to			Percentages of decrease in the cost of living on March 1, 1921, from average prices in	
		July, 1920.	February, 1921.	March, 1921.	July, 1920.	February, 1921.
Food	43.1	119	72*	58*	27.9	8.1
Shelter	17.7	58	66	66	5.1†	No change
Clothing	13.2	166	74	69	36.5	2.9
Fuel and light	5.6	66	48	97	18.7†	.5
(Fuel)	(3.7)	(92)	125	(120)	(14.6†)	(2.2)
(Light)	(1.9)	(15)	45	(52)	(32.2†)	(4.8†)
Sundries	20.4	85	90	85	No change	2.6
Weighted average of all items	100.0	104.5	76.3	68.6	17.6	4.4

*Food price figures are for the 15th of the preceding month, from the United States Bureau of Labor Statistics. †Increase.

The continued downward movement in the cost of living during February was due largely to the big drop in the cost of foodstuffs as shown by the Bureau of Labor Statistics index numbers of retail food prices. Average clothing prices declined slightly, although there was an increase in the cost of a number of items in the woman's clothing budget. Average rents remained stationary; the cost of coal and of certain sundries dropped while average rates for light advanced.

Power Production in the United States.—Some interesting statistics regarding the production of power in the United States were given by Mr. David B. Rushmore, Chief Engineer Power and Mining Department of the General Electric Co. in a recent address before the Engineers Club of Philadelphia. He stated that in 1920 the average daily production of electricity was approximately 120,000,000 kw. hours and of this approximately 40 per cent was produced by water power and 60 per cent from fuel. The total fuel consumption for the year 1919 was: Coal, 35,000,000 short tons; oil, 11,050,000 bbl., and gas, 21,700,000 M. cu. ft. The total coal mined is approximately 650,000,000 tons. Its use is divided as follows:

		Per cent.
Used in industrial plants	28	
Coal for coke make (steel industry)	13	
Total in industries		41
Coal for public utilities		5
Railroads		28
Domestic		16
Export		4
Steamship bunker coal		2
Coal gas		1
Miscellaneous		3
		100

It is interesting to know that of the total power used by industrial plants the last census showed that but 16 per cent was supplied by public utilities. Of the heat generated by coal used in industry about 50 per cent is charged to power and 50 per cent to process work and to heating. Because of the necessity in industrial work for the use of heat for process manufacturing and for heating, 33 per cent of the number of industrial plants are considered by engineers to offer no hope for the sale of power from public utilities. These represent the larger plants of the industries and a very much greater proportion of the power consumed in manufacturing.

Personals

David J. Nason has been elected city engineer of Bangor, Me.

J. B. McKee has been elected city engineer of Plattsmouth, Neb.

Nels J. Anderson has been elected city engineer of Stromsburg, Neb.

W. H. Houser has been elected city engineer of Blue Springs, Neb.

Charles M. Reppert, consulting engineer with Morris Knowles, Inc., Pittsburgh, Pa., has been appointed chief engineer of the Department of Public Works of Pittsburgh, Pa.

Dr. Ernest Fox Nichols, former president of Dartmouth College, has been appointed president of Massachusetts Institute of Technology. He will take office July 1. Dr. Nichols has been a professor of physics at Yale University and has been engaged in private research work for the last year. He succeeds the late Dr. Richard C. MacLaurin, who died more than a year ago. During the war Dr. Nichols developed valuable optical devices for the Bureau of Naval Ordinance. As a student at the University of Berlin from 1894 to 1896 he discovered the metallic reflection of quartz and its anomalous dispersion in the infra red spectrum, leading to what was characterized as a wholly new method of spectrum analysis.

Industrial Notes

The Western Wood Pipe Publicity Bureau, in order to follow more closely the irrigation, water supply and other hydraulic developments of the great southwest as well as provide closer contact with the California companies it serves, has opened an office at 775-777 Monadnock building, San Francisco, Cal.

The Clyde Iron Works Sales Co. of Duluth, Minn., has recently announced three new agency connections in the eastern portion of the United States. Its line of contractors' equipment has been placed with Edelen & Co., Philadelphia; Queen City Supply Co., Cincinnati, and Waldo Bros. & Bond Co. of Boston. The sales territory handled by the last mentioned company will comprise all of the New England states.

The Engineering Business Exchange announces the opening of a southeastern branch with Marshall O. Leighton, consulting engineer, of Washington, D. C., as director. Mr. Leighton was for a dozen of years one of the principal officers of the United States Geological Survey. During the past three years he has been chairman of the National Service Committee of the Engineering Council. Associated with Mr Leighton in carrying on the exchange will be A. C. Oliphant, who was also active in the work of the Engineering Council's National Service Committee. The southeastern branch of the Engineering Business Exchange has offices in the McLachlen building, Washington, D. C. It will co-operate with the main office of the exchange in New York City in the conduct of business, but will have especial charge of the territory from Maryland to Alabama, inclusive.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Tanks.—Youngstown Boiler & Tank Co., Youngstown, O. 20-page illustrated bulletin on storage tanks.

Service Box.—H. W. Clark Co., Mattoon, Ill. Circular illustrating and describing new C. M. B. service box.

Tanks.—Lancaster Iron Works, Lancaster, Pa. Circular on horizontal oil storage tanks, pressure tanks, and standard field storage tanks.

Water Supply and Turbine Pumps.—Layne & Bowler Co., Memphis, Tenn. 64-page bulletin on the development of ground water supplies and deep well pumping machinery.

Pump Governor.—Atlas Valve Co., 282 South St., Newark, N. J. Bulletin describing the Ideal pump governors; contains drawings and explanation of installation and operation.

Railways and Excavation Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Scientific Research and the Bell Telephone System

Scientific research already claims the services of several thousand engineers, chemists and physicists in America. Most of these men are employed by great industrial companies. Not long ago we read that the du Pont company employs more than a thousand chemists in its research laboratories. In the last annual report of the American Telephone & Telegraph Co. (the Bell System) we read:

> The year just closed has been one of remarkable activity in the Department of Development and Research. In this department, including the laboratories at the Western Electric Co., 2,800 employes are engaged exclusively in research and the development and improvement of telephone and telegraph apparatus and materials and methods. Of these, 1,100 are engineers, chemists, physicists and other scientists, among whom are graduates of more than 100 American colleges and universities. The remainder are laboratory assistants, draftsmen, stenographers, clerks, model makers and administrative personnel.
>
> At the close of the year, upwards of 2,500 research and development projects were in hand, all these calculated to improve the service which the associated companies are rendering to the public or to make it more economical.
>
> During the year hundreds of new patents relating to the telephone and telegraph, issued in various countries, have been examined and studied; the latest discoveries in science have been followed with care by our scientific staff, and over 1,000 United States patents relating to telephony and telegraphy have been applied for by, or issued to or acquired, for the use of this company. Not only has attention been given to fundamental improvements in transmission and in apparatus and materials, but minute care and study have been devoted to improvements in the thousands of diversified parts which are required for the most effective and economical operation of the Bell System. In the magnitude of its operations, the number of its personnel, and in the size and equipment of its laboratories, this research and development organization far exceeds that maintained by the telephone and telegraph administration of any government or by any other corporation engaged in similar or related work.

Electrical, chemical and metallurgical periodicals contain many articles relating to research work, but civil engineering periodicals contain relatively few. This may be ascribed, we think, to the fact that the great majority of civil engineers are employed by the public and by railways and other public utility companies. The public has yet to be taught the enormous value of experiment and scientific investigation. Managers of railways and other public utilities have been so busy trying to get adequate rates during the past decade that little of their time has been devoted to a consideration of the value of research work. Moreover, where is the incentive to reduce costs if public service commissions stand ready to lower rates as soon as lower costs enable them to do so?

The Bell Telephone System has been singularly fortunate among utility companies in having been evolved from one great invention. With the striking example of its founder before it, we need not wonder that the American Telephone and Telegraph Co. became a pioneer in research, for research is, after all, little else than organized invention and discovery. Moreover, the telephone "monopoly," incomplete though it was as a monopoly, was not ruined by excessive competition or by the ever present fear of municipal ownership. In these respects the Bell System differed from most of our railways and other utilities.

Finally, the stock of the Bell System has long been widely distributed. There are, in round numbers, 140,000 shareholders, exclusive of about 20,000 employes who are buying stock on the installment plan. Of American corporations the company is third in the amount of stock outstanding, but it is first in the number of shareholders. The effect of this wide distribution of stock has been to remove the Bell System from the arena of "high finance" and from the control of men more skilled as market manipulators than as industrial managers. It is also of interest to engineers to know that a great many engineers occupy important managerial positions in the Bell System.

Occasionally some politician urges government ownership of telephones, and points to Europe for example of such ownership. But the pointing is rarely to the relative growth of telephone service, and never to the relative quality of service nor to the relative progress in the art. America stands so far ahead of every other nation in telephone service and telephone progress, that there is no comfort to government ownership advocates in telephone statistics.

Prospective Changes in Wages and Salaries

That daily wage rates have risen much more than weekly or monthly salaries is known to all business men. But what the average difference in the increasement has been is a question that is only just beginning to be answered convincingly. U. S. census data as to manufacturing industries are now available for six states (Delaware, South Dakota, Colorado, Wyoming, Nevada and Arizona) and the District of Columbia, and they show that for the year 1919 the average yearly payment to wage earners was $1,274, as compared with $580 for 1914, or an increase of 120 per cent; whereas the average salary paid for the year 1919 was $1,930, as compared with $1,338 for 1914, or an increase of only 44 per cent. In other words, during those five years wages increased almost three times as fast as salaries.

It is probable that when the entire manufacturing census shall have been completed, we shall find no great departure from the data relating to the six states above named.

The U. S. Bureau of Labor has recently published an "index" of hourly wages that shows a raise of 134 per cent between 1914 and 1920; but as there was a 6 per cent reduction in the average number of working hours in the week, it may be estimated that the increase in the weekly wage was 120 per cent, which exactly corresponds with the wage increase indicated by the census of manufacturing in the six states.

We believe that the census of manufacturing in the entire country will show an average increase of wage rates amounting to a trifle more than 100 per cent, as compared with an increase of about 50 per cent in salaries.

The great "smelting trust" has just announced a reduction of 30 to 40 per cent in wage rates and 20 per cent in salary rates, the difference being due to the greater increase in wages during the war.

For reasons previously given, it is our belief that wages and commodity prices will eventually settle at a level about 60 per cent above the pre-war level. Therefore, if the average wage is now 100 per cent above the pre-war level, or an "index" of 200, there will occur an average decrease of 20 per cent in wages. If average salaries are now at an "index" of 150, there will be an average increase of 6 per cent in salaries.

Bear in mind that many clerks, accountants and professional men are still working at salaries but slightly above the pre-war level, and that their salaries will surely rise eventually. Many, it is true, are working at salaries that are 75 to 100 per cent above the pre-war level, and most of them must face a decrease in salary.

Book Review

Maintenance of Way Cyclopedia, a Reference Book. Compiled by E. T. Howson, Western Editor of the Railway Age and Editor of the Railway Maintenance Engineer, and other engineers in co-operation with a special committee of the American Railway Engineering Association. Simmons-Boardman Publishing Co., Woolworth Building, New York. 1921. 9x12 in., 860 pp., 2,500 illus. Buckram, $10; leather, $15.

This review will be confined to a general survey of the contents of the volume, and the single comment that it is true to its title and is so well balanced and of such uniform merit as to leave no reason for discussion of particular features or items. The book is divided into 8 sections, in each of which the subjects are arranged alphabetically. The sections are (1) Track, (2) Bridges, (3) Buildings, (4) Water Service, (5) Signals, (6) Wood Preservation, (7) General subjects, (8) Catalog Matter.

In the first 7 sections are included definitions, descriptions, illustrations and methods of use of the materials, tools and equipment employed in the maintenance of the fixed properties of railways. In an effort to standardize terminology and avoid the confusion resulting from carrying local usages of many words, the nomenclature of the Manual of the American Railway Engineering Association has been followed except in a few cases where better known trade names have been substituted.

Typical examples of subjects defined or treated are as follows: In the Trade Section—Alinement, Clearance, Derail, Dump Car, Easement Curve, Fence, Frog (15 pages with many illustrations and sub-heads), Station Ground, Switch Key; in the Bridge Section—Arch, Bolt (Drift, Hook, etc.), Continuous Beam, Culvert, Reamer, Turntable, Water Jet; in the Building Section—Brace, Coaling Station, Ice House, Metal Lath; in the Water Service Section—Hardness, Intake, Meter Spillway; in the Signal Section—Ampere Hour, Block System, Dog Chart, Phase, Signal Bridge, Wire; in the Wood Preservation Section—Annual Ring, Creosote, Knot, Pecky, Teredo; in the General Section—Anneal, Brush Hook, Camp, Cement, Engine (Gas), Material Testing, Vise, Warp.

The volume includes the latest revisions of specifications adopted by the American Railway Engineering Association, the American Railway Association, the Railway Signal Association, the American Wood Preservers Association and the Manganese Track Society. It also includes sets of instructions to inspectors, full diagrams of switch layouts, etc. The illustrations vary from half tone pictures of large structures and pieces of equipment to drawings of small details such as spike dimensions. Signal systems are illustrated in much detail.

The Catalog Section is arranged alphabetically by names of manufacturers. It is partly of an advertising character, and is obviously limited in the number of its references, but nevertheless it supplements the text advantageously. As a time saver, page references to the catalog section are made throughout the text.

At the front of the book there is provided an index of about 2,000 references, which covers all the subjects treated in all the sections, thus adding to the convenience of reference and giving assurance that in doubtful cases a subject need not be missed. There are further provided a directory of manufacturers, arranged alphabetically by products, a trade name index of the Catalog Section products, and an alphabetical index of manufacturers represented in the catalog.

Revolving Funds Railroads Loan

Out of the $300,000,000 revolving fund created by Section 210 of the Transportation Act, the following loans have been made:

Atlanta, Birmingham & Atlantic	$ 200,000
Baltimore & Ohio	3,000,000
Bangor & Aroostook	20,000
Boston & Maine	11,656,479
Buffalo, Rochester & Pittsburgh	1,000,000
Carolina, Clinchfield & Ohio	3,000,000
Central New England	300,000
Chicago Great Western	2,445,373
Chicago, Indianapolis & Louisville	200,000
Chicago, Milwaukee & St. Paul	25,340,000
Chicago, Rock Island & Pacific	9,862,000
Chicago & Western Indiana	8,000,000
Erie	8,000,000
Fort Smith & Western, receiver	156,000
Great Northern	17,910,000
Gulf, Mobile & Northern	515,000
Illinois Central	4,440,000
Kansas City, Mexico & Orient, receiver	2,500,000
Maine Central	1,653,000
Missouri Pacific	8,871,760
New York Central	26,775,000
New York, New Haven & Hartford	6,730,000
Northern Pacific	6,000,000
Pennsylvania	6,780,000
Rutland	61,000
Salt Lake & Utah	300,000
Seaboard Air Line	6,073,000
Trans-Mississippi Terminal	1,000,000
Terminal Railroad Co. of St. Louis	896,925
Virginian	1,000,000
Waterloo, Cedar Falls & Northern	60,000
Western Maryland	300,000
Wheeling & Lake Erie	1,400,000
Total	$166,445,937

Production and Use of Explosives.—In a recent bulletin of the U. S. Bureau of Mines, it is intimated that there are probably more than 500,000 individual consumers of explosives in the United States. The bulletin states that in normal times over 31,000 mines and quarries use explosives. About 55,000 wholesale and retail dealers handle explosives and over 18,000 concerns engaged in the construction of railroads, highways and waterways use explosives. Altogether, there are over 100,000 concerns using such comparative large quantities of explosives that special magazines for their storage are an absolute necessity. The production of explosives in 1919 in the United States, according to the Bulletin, totaled 416,634,470 lb.

How Much Conceit Is Beneficial?

When a young man finishes college and begins work in earnest, he finds himself the object of an indirect campaign to "take the conceit out of him." His elders and business associates see to it that he gets only such work and consideration as will show him how small he is in the scheme of things. If he doesn't have good luck and get promoted within a reasonable time, he is likely to feel downcast and to be glad to cling to the industrial machine by any kind of insignificant job. Especially if he has the temerity to marry within a year or two after finishing college and before he has established himself, he loses his conceit almost entirely and becomes as meek as any employer could wish.

The question is, Should young men be bullied out of their conceit? Whiting Williams, author of "What's on the Worker's Mind?" thinks that conceit is what makes complicated and highly specialized industry possible, and he advocates that employers encourage their men to feel their individual "worth-while-ness." He explains that the mechanic comes regularly to his bench and the millionaire to his desk, and make sincere, valuable citizens because each feels that he is an important part of the industrial fabric. Each one, though he has grievances and further ambitions, is proud of what he has achieved and can do, and this pride brings him daily to his work and adds zest to what otherwise would be drudgery. As an experienced personnel-manager, Mr. Williams suggests that this self-pride or individual conceit is the very basis of the social system. Labor unrest comes rather from the neglect of employers to permit their men this incentive than from differences about wages and salaries, says Mr. Williams. There are more foremen and officials who take unnecessary joy out of life than there should be for healthy conditions, is the conclusion of his book, written after seven months spent working as a common laborer in overalls. In other words, too many of the wrong kind of bosses have been promoted, and their driving, narrow ways have brought resentment. Common laborers, as well as young engineering graduates, have been given too little opportunity to feel the sense of individual worth-whileness that Mr. Williams recommends. After all, as so many philosophers from Plato to Herbert Spencer, have pointed out, each individual is the center of his own world. Everything revolves around the ego, in spite of temporary campaigns to discredit individualism. The most important thing to each man is himself. When he feels moderately happy, great accomplishments are possible; when he is browbeaten and depressed, he is a force for evil in the world.

The nation which has most encouraged individualism is England. Just as an example, a letter to the London Times generally receives respectful consideration both from the editor and from a wide circle of readers; they have learned that excellent suggestions are made in that way, that national benefits accrue from permitting individuals to express themselves, as the canny Adam Smith long ago pointed out. In spite of the hamperings of class distinctions in British society, individual genius is probably more quickly recognized than in America. Those in control of things there are influenced by a tradition to help original thinkers who appear to possess talent of value to the nation.

In America there is, of course, what is called "rampant individualism," but it results in everyone being so busy with his own affairs or so shortsighted in his own troubles that the young man of exceptional talent is as likely to remain unrecognized as not. Why was it, for instance, that Herbert Hoover found more scope for his extraordinary ability in London than in America, at least until he was a well-known and successful engineer? Without doubt, if he had been a more conventional type he would have found plenty of opportunities in this country, but because his combination of gifts was of the kind that the ordinary American employer did not recognize, he found more attractive openings in British firms directed from London.

Taking a historical case, the record of Benjamin Thompson, who died over a century ago, shows that that notable scientist and administrator found instant recognition and encouragement in Europe, where he was made Sir Benjamin Thompson in England and Count Rumford in Bavaria. In America, although he was of an old New England family, he encountered only enmity and jealousy. It is true that he left his fortune to Harvard College, but most of his work benefited Europe, since he founded the Royal Institution in London and has a statue to his honor in Munich. It was a pity that America did not profit more by his unusual talents in both pure and applied science—such as his researches in the physics of heat and his experiments with explosives.

These are not the only Americans who have found greater success abroad than was possible in their own country. Many others could be mentioned, and many more who never had the chance to try their fortunes abroad undoubtedly would have succeeded better there than here. In other words, Europe is quicker to recognize certain kinds of talent than is America, not only in literature and art—as is commonly admitted—but also in engineering and general science. America is quicker than Europe to help certain other kinds of ability; we all know of immigrants who have amassed a fortune in short order. But the point is that it is more important to recognize ability among native Americans, such as Hoover and Thompson, than to make the fortunes of Italian or Russian immigrants. The good that a great constructive thinker or critic can do is more essential to the nation than is the operation of the corner fruitstand or the business of a get-rich-quick Ponzi. America's first consideration should be the encouragement for her own young men to express themselves in ways helpful to national interest.

That young men are conceited is an excellent sign. Instead of bullying them into forgetting their ambitions, the men in control of industry should take youth more seriously and train it more broadly and more sympathetically, granting opportunities that appeal to the adventurous and eager. In Germany, before 1917, visitors remarked that when the Kaiser or his generals passed down the street, people literally held their breath. That was conceit grown unhealthy beyond all reason, but the moderate conceit that Mr. Williams advocates is healthy and beneficial.—Editorial in Chemical and Metallurgical Engineering.

Incentives for Greater Production

The incentives which induce men to labor in railroad shops, or any branch of railroad or industrial service, may be summed up as wages, opportunity for training and advancement, and confidence in the security of their positions. Under present conditions, the third of these factors has little effect on the personal efficiency and output of workmen, since it is practically impossible to discharge a man as long as he reports for work and does not absolutely refuse to obey orders. The first two incentives mentioned, however, may or may not provide increased production, depending upon conditions. It is only human to expect a special reward for unusual endeavor, and production managers throughout the country have found the installation of bonus or piecework systems, whereby wages are proportional to the work done, an effective method of increasing the personal efficiency and output of workmen. While there is no pressing need at present for greater railroad shop output, it is undoubtedly true that within a few months at the most the railroads will once more be working to capacity, and will want to install every possible capacity and efficiency-increasing method in railroad shops. One of the strongest arguments against the continuance of the national agreements is the fact that they prohibit piecework and eliminate the incentive for greater individual output. Ordinarily, the opportunity for securing training and advancement impels ambitious workmen to strive for higher positions, but railroad shop managers are denied the benefit of this incentive, also, since, under the national agreements, promotion must be made in accordance with seniority rules and length of service. It is time that the capacity decreasing rules and regulations, promulgated by the national agreements, be revoked and railroad shops brought up to the same standard of efficient, economical operation as other industrial plants.—Editorial in Railroad Age.

The Drill Steel Problem

A real problem confronts the makers and users of rock drill steels. At the February meeting of the mining and metallurgical engineers, it was emphasized that the failures of such steel in actual use run as high as 7 per cent per shift in the case of heavy drills and is excessive in other cases. The waste merits the research planned as summarized in The Iron Age, Feb. 24.

Steel incorporated in drills for mining purposes is subjected to notoriously harsh treatment. It is usually a hollow hexagonal tool steel delivered to the user as long rods. In its fabrication into a drill it is subjected to a heating and forging by a man at the mine, under [illegible] which do not favor scientific attention. Then in actual use it is under many varied stresses in drilling operations which are exceedingly severe. It must be capable of taking a sharp cutting edge and yet be able to withstand [illegible] vibrations from the driving piston or the hammer blows of the sturdy miners. There is evidently needed an almost flawless steel of considerable hardness and yet tough and sound enough to stand up against severe shocks and at the same time capable of a heat treatment that is reasonably fool-proof.

The present carbon drill rod steels do not seem to meet fully the requirements. While fatigue may be a major cause of the failures, Prof. H. F. Moore claimed no case of steel failure under repeated stress was found which could not be explained as arising from some physical defects or overstrain in the steel, and not in an alteration in crystallization or elastic limit.

The solution of the problem may be found in some alloy steel. The proper steel needs to have a wide heat-treatment range. Of prime importance is the use of a process of manufacture to insure a steel as flawless as possible. There still remains further education of the forgers at the mine or the employment of proficient heat treaters. The solution of the problem is assured by the co-ordinated efforts of the steel maker, the steel treater and the research engineer.—Editorial in The Iron Age.

Test to Determine Cost of Pneumatic Tie Tamping

A test was recently conducted by the Delaware, Lackawanna & Western Ry. in conjunction with the Ingersoll-Rand Co. of New York, for the purpose of establishing some basic cost data on pneumatic tie tamping. The test was made on a stretch of main line track between Boonton, N. J., and Lincoln Park, the railroad furnishing the equipment and men to do the work. The plant consisted of an Ingersoll-Rand 4-tool compressor with hose and tampers. The work was done by a contractor who paid his men 55 ct. an hour, but the data on the test have been compiled in such a way that the cost for any other rate of pay may be readily ascertained. We are indebted to the Railway Age of March 18 for the following details:

The Lackawanna required that only such time and other costs be charged as actually applied to the machine and its operation in the performance of its duty of tamping ties, and on that basis the following methods were used. For instance, the machine being a four-tool outfit, four men were used on the "guns" or tampers and their time was charged only when actually employed tamping. The foreman's time was charged only during the period that the machine was in actual operation, while the operator's time was charged for the full day whether or not the machine was in actual use. This was done in view of the fact that it was deemed good policy to have the operator go over his machine carefully and thoroughly when not in operation.

The gang consisted of 40 to 50 men. However, only those actually working with the machine were charged to tamping. Such work as jacking up the track, cleaning the ballast, replacing ballast, putting in new ties equipped with tie plates and screw spikes, was conducted by the remainder of the gang. The ballast consisted of crushed stone of 2½-in. mesh, with 105-lb. rail laid on creosoted ties with tie plates and screw spikes, all of the Lackawanna standard specifications.

The man compiling the data was in no way connected with the operation of the machine nor did he make any repairs and, with the exception of selecting a capable operator and instructing him originally in its operation, etc., he had nothing to do with the machine. The operator was not a mechanic, and, although he was fairly familiar with automobiles, he possessed no particular qualifications with reference to the machine or its operation. The men used on the tampers were all picked at random and were changed about every three or four days so that no specially trained men were used in connection with the operation of the machine or the tampers. In determining the number of ties and the lineal feet of track tamped, owing to the fact that the track was raised as high as 6 in. in many instances, run-offs were necessary and such ties as were tamped in the run-off as well as the lineal feet covered were counted in on the total for the day.

Throughout the duration of the entire test, which covered eight consecutive weeks, the tamping outfit was out of service 2½ hours, of which 1 hour was due to the battery being exhausted and time consumed in waiting for a renewal, while the remaining 1½ hours was due to dirt and water, making it necessary to remove and clean the carburetor and feed pipe. All the time so consumed was charged against the machine.

The summary of the results shows that for the eight weeks' run the average cost for tamping, including all items, was 11.3 ct. per tie or 6.2 ct. per lineal foot of track.

To determine a fair comparison or equation it is necessary to separate the average total cost into its component parts and to then reduce each part into its determining factors. These factors consist of a constant which, multiplied by the wage scale, will give the cost per tie for that particular item of the total cost. In reducing the total cost of $1,155.92 for tamping 10,226 ties or 18,358 lin. ft. of track, it will be found that this is made up as follows:

Items.	Cost.	Per cent.	Cost per tie, ct.	Constant.
Foreman	$ 169.06	14.62	1.65	0.024 × wage
Operator	258.50	22.36	2.53	0.046 × wage
Labor	565.40	48.90	5.52	0.103 × wage
Gasoline	148.06	12.82	1.45	0.053 × price
Oil	9.38	0.81	0.10	....
Grease	2.04	0.18	0.02	....
Repairs	3.48	0.31	0.03	....
Total	$1,155.92	100.00	11.13	....

The constant as shown in the right-hand column consists of the figure which, multiplied by the wage scale of the man or men doing the work of tamping, will give the cost per tie for tamping by compressed air. For example, with a foreman receiving $5.27 per day, or 66 ct. per hour, with labor at 46.4 ct. per hour and gasoline at 27½ ct. per gallon the proportionate cost per tie would be 0.024 times 66 or 1.58 ct.; 0.046 times 46.4 or 2.12 ct.; $0.103 times 46.4 or 4.78 ct., and 0.053 times 27.5 or 1.45 ct. This adds up to 9.93 ct., to which should be added 0.15 ct. for oil, grease and repairs, this cost remaining practically the same with the machine in good order. The result is a total cost of 10.08 ct. per tie for tamping pneumatically or on a basis of 20 ties per rail length, a cost of 6.11 ct. per lineal foot. Other wage scales may be substituted in the manner outlined and the basic cost for any particular piece of work derived.

Blasting Pole Holes.—Any kind of dynamite will blast a hole in the ground, but not the kind of a hole a construction foreman wants. A telegraph or telephone pole hole should not be any larger than necessary and the soil around it should not be loosened up any more than is necessary. If it is, the pole is apt to lean.

Mr. Frank A. Huntington, of New York, reports that he has good success with a straight N. G. "fast" dynamite in getting holes in shale. The dynamite was loaded in a bore hole put down to within 6 in. of the desired bottom. The charge was not tamped. The fast dynamite blew out a nice vertical hole, having not much more spread than would be made with long-handled shovels. The surrounding soil was not disturbed enough to hurt. The charge used in each hole was 1¾ lb. For hard clay, 1 lb. or even less would doubtless be sufficient. But it is easy to decide on the proper charge after noting the effect of one or two trial shots in the soil in which the blasting is being done.

U. S. Chamber of Commerce to Consider Plans for Solving Railroad Problem.—Proposed plans for reducing the cost and increasing the efficiency of railroad transportation in the United States will be discussed by representative business men from all parts of the country at the Ninth Annual Meeting of the Chamber of Commerce of the United States to be held at Atlantic City April 27 to 29. This discussion will take place at the railroad group meeting to be held on the first day of the annual meeting. Speakers will include a prominent railroad executive, a large shipper, a leading banker and an eminent engineer. In addition to these special speakers, there will be a general discussion of the whole railroad question in which the different railroad interests will participate. In this way, the National Chamber hopes to bring about a greater degree of co-operation and understanding between the different groups and thus aid in the development of a plan looking to a solution of the railroad problem.

Theory and Practice in the Drill Sharpening Shop

It is becoming generally recognized that the rule of thumb methods usually followed in the drill sharpening shop must be supplanted by a systematic yet practical application of known facts about the physical properties of high carbon steel. Some useful practical suggestions regarding the proper heating, forging and tempering of this material are given in the April issue of Mine and Quarry by J. A. Noyes and Frank M. Lee. The matter following is taken from their article:

Steel is not a simple substance like gold or silver. It is a complex, artificial product made up of many elements. In our consideration of drill steel, the most important of these elements are iron and carbon. Iron with 2.5 per cent carbon or over is cast iron. Iron with 0.03 per cent carbon or less is wrought or ingot iron. Steel lies between these two, the carbon content of drill steel averaging from 0.50 per cent to 1.2 per cent. The carbon content makes the steel susceptible to heat treatment and also increases its tensile strength and decreases its ductility and otherwise affects its physical properties, particularly during heating, forging and cooling.

In the last few years the greatest strides in the metallurgy of steel have been in the art of heat treatment. Until recently very little scientific knowledge was available regarding the heat treatment of steel, the art being limited to the practical blacksmith's experience. For example, in his determination of the temper of steel he depended on the unreliable method of watching the color. Even his knowledge was beclouded with uncertainty and secrecy In the automobile industry every conceivable variety of alloy steel is developed to its full value by elaborate and exact heat treatment processes, and this industry is responsible for much of the treatment. Any steel in its natural state does not present its full value.

In the drill shop only one class of steel is used and only one result is wanted. In the majority of the drill steel shops, however, the improvement to be secured by the simple application of a few known facts about the proper heat treatment of steel is unbelievable. The cost of affecting these improvements is infinitesimal compared to the enormous saving made. The saving is not only in steel, by having less breakage and less labor and handling cost in the blacksmith shops; the greatest saving shows up underground in the improved performance of the steel at its work of drilling rock.

The heat treatment of drill steel starts with the initial heating preparatory to forging. If the initial heating for forging or the forging operation itself is improperly carried out, any later attempt at heat treatment in the way of securing a proper temper for the drill bits is a useless effort to get something out of the steel that is not there.

Importance of Critical Range.—In the discussion of the proper forging and tempering temperatures, mention of the critical range or the critical point of the steel is frequently made. A practical understanding of what is known as the critical range can be had by watching the slow heating of a piece of steel in the furnace. The steel brightens in color with the rising heat of the furnace until a point is reached where the steel apparently becomes a trifle darker and cooler than the furnace. If the heating continues, the steel again increases in brightness, once more assuming the same brilliancy and temperature as the furnace. The darkening is due to the absorption of heat and the temperature at which this absorption takes place is known as the decalescent or critical point. At this point the Ferrite and Pearlite are converted into Austenite. If the furnace is now allowed to cool slowly, a point will be reached where the steel remains visibly brighter than the furnace, but in a few seconds it again assumes the color of the furnace and darkens with it. This brightening of color is due to the throwing off of heat and is the recalescent point, where the Austenite changes back to Ferrite and Pearlite.

The decalescent point on the rising heat is at a higher temperature than the recalescent point of cooling. For practical purposes, the critical point is the decalescent point and the critical range includes the temperatures just above the critical point. The critical point of steel is different for steels of different carbon contents. For drill steel averaging 0.60 per cent to 0.90 per cent carbon, the critical range is from 1,420° F. to 1,350° F.

By coincidence this steel becomes non-magnetic at a temperature, which for all practical purposes is the same as the critical temperature of the steel. This fact therefore affords a simple, easy method of determining the critical point of any drill steel regardless of its carbon content. By bringing the heated drill bit up close to an ordinary horseshoe magnet, it can be determined whether or not the temperature of the bit is above the critical range of the steel by merely noting whether or not the magnet is attracted by the hot steel. If the magnet is attracted, the temperature is below the critical point. If it is not attracted by the steel, the critical temperature has been passed.

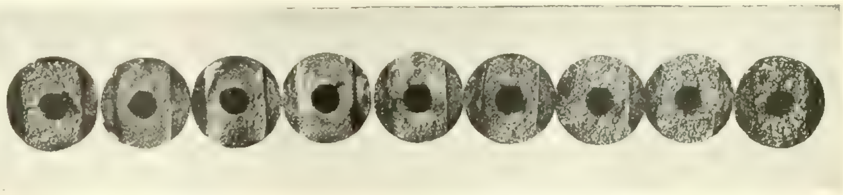


Fig. 1.—Fractures in Piece of Hollow Drill Steel.

Hammering Improves Steel.—The resulting structure and physical properties of the drill bit depend absolutely on the temperatures used for heating the steel preceding both forging and quenching, as well as on the care exercised in the mechanical working or forging of the bit. The finest grain size obtainable exists just as the steel passes through the critical range on the rising heat. Further heating above the critical temperature coarsens the grain, and this coarse structure remains in the steel if it is allowed to cool undisturbed. If, instead of allowing the steel to cool undisturbed, it is vigorously hammered, the coarse crystalline structure can be broken up and the grain refined. If, however, the hammering is stopped above the critical range, the coarse crystallization sets in again, and the higher the temperature above the critical range at which the forging stops, the coarser the structure will be. The finishing temperature for the forging operation of the drill steel bit should therefore be at or slightly above the critical temperature, and the forging should be by rapid, vigorous hammering and not by bulldozing or squeezing. It is a well known fact that hammered forgings command a much higher price than drop forgings, where the metal is literally pressed into shape at high temperatures. The forging operation should not continue below the critical range, because "cold working" below this heat causes distortions and internal strains, which result in brittleness and in steel breaking.

Figure 1 shows several fractures of a piece of hollow drill steel. The bar was nicked on both sides with a hack-saw at distances 1 in. apart, starting from one end, then heated in a furnace until the extreme end of the steel was at a white heat and the heat graduated back to the last notch, where it was cold. The steel was then quenched in water and broken off at the places previously nicked. Section A shows the natural condition of the cold bar. Section B shows the same structure as Section A. Section C shows the finest grain size possible, as here the critical temperature has been reached and at this point the steel has the qualities of toughness, and maximum density, with maximum hardness. The other sections from D up to I show increased coarseness of structure. Sections H and I were very badly burned. Steel in this condition is granular, brittle and useless for making a wear-resisting drill bit. Section E shows the structure of the steel at the maximum temperature permissible for starting the forging operation.

Even Heating Essential.—Heating in a coal forge is unsatisfactory, as the abundance of oxygen required for the combustion of the coal gives a heavy oxidizing flame, causing excessive scaling of the steel. Coke is only slightly better as a fuel. With both coal and coke furnaces, it is nearly impossible to get a close regulation of temperature. In heating steel, it expands, except in passing through the critical range, at which point it contracts. Therefore, if a piece of cold steel is thrust into a raging hot fire, the outer surfaces are passing through the critical range and are contracting, whereas the center of the bit is still expanding, having not yet reached the critical temperature. This causes cracking and checking of the steel. In the same way, even if the steel is not thrust directly into a raging open fire, but is only inserted directly into the combustion chamber of a furnace, where the extreme high temperature flames are allowed to impinge directly against the drill bits, this same condition will result, and either cracking or checking of the bits takes place. It is a well known fact that if the higher carbon steels are allowed to remain in a hot furnace for any great length of time the carbon is precipitated in the form of graphite, and when this occurs, the steel is greatly reduced in efficiency, even if not entirely ruined. It is common practice in drill sharpening shops for the toolsmith to allow the drill steel to remain in the furnace while making adjustments on the drill sharpening machine, changing dollies, or making minor repairs, and this is sure to prove costly in the end, as the outer surface of the steel becomes decarbonized and will not respond to the same heat treatment that is effective before the "soaking" takes place. This "soaking" also increases the coarseness of structure, as coarseness of structure not only increases with high temperatures, but also with the length of time for which the steel is held at the high temperature. The maximum temperature for forging drill steel should not exceed 1,650° to 1,750° F. Temperatures higher than this coarsen the structure to such an extent that even the thorough hammering during the forging operation cannot again refine the grain. The result of too high a forging heat is checked, cracked and brittle bits, irrespective of what the subsequent tempering treatment may be.

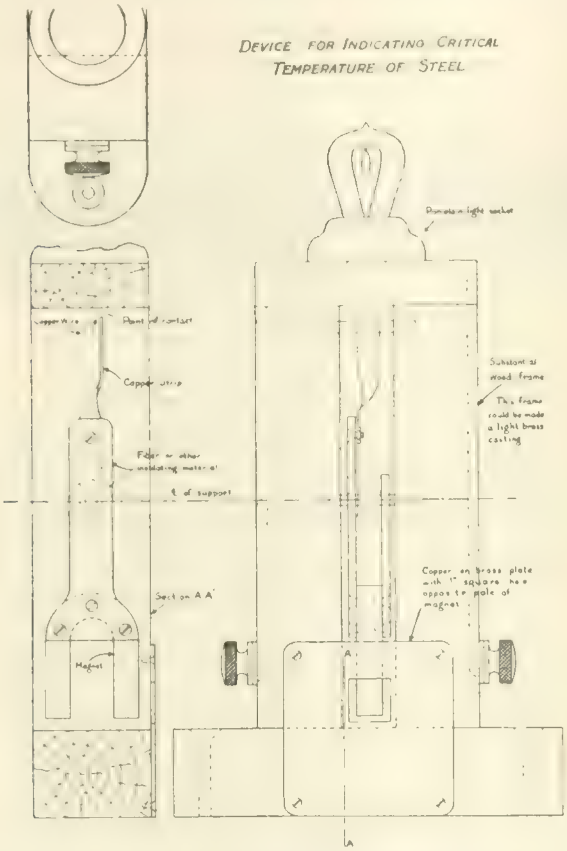

DEVICE FOR INDICATING CRITICAL TEMPERATURE OF STEEL
Porcelain light socket
Copper Wire
Point of contact
Copper strip
Fiber or other insulating material
℄ of support
Sect on A A'
Magnet
Substantial wood frame
This frame could be made a light brass casting
Copper or brass plate with 1" square hole opposite pole of magnet
A

Fig. 2.—Device for Indicating Critical Temperature of Steel.

Overheating Ruins Steel.—In tempering all drill bits, quenching should take place at the critical temperature or at about 50° F. above this point and on a rising heat. When quenching takes place at this temperature, maximum density and toughness, with maximum hardness, are secured. The heating preceding the quenching should be slow, uniform, and thorough, and at the lowest possible temperature that will secure the desired results. The furnace temperature should be slightly above the critical point of the steel to compensate for some loss of heat while transferring the steel from the furnace to the quenching bath. Heating for quenching cannot be done satisfactorily in a coal or coke furnace, where close regulation of temperature is impossible. Overheating is the cause of 90 per cent of the bad results from drill steel. Unfortunately many practical blacksmiths still believe in the efficacy of high temperatures for greater hardening effect. While to a very limited extent, it may hold true that the higher the temperature the harder the steel, the questionable gain in hardness is more than offset by increased coarseness in the grain of the steel, and by internal strains, both resulting in faster wear on the bits, and more breakage. Heating for hardening requires great care. The rapid quenching of hot steel is the most severe test that steel can be put to. If the heating is not uniform, it naturally follows that the bit after quenching will be subjected to severe internal strains. Hardening cracks are therefore more often a result of improper heating than of any defect in the steel.

To emphasize the importance of quenching the steel at the lowest possible temperature and still be above the critical point, we cite a test that was made on two gears that were machined from the same bar of steel, and given identically the same heat treatment, with the single exception that gear B was quenched at a temperature of 50° higher than gear A. Both gears showed the same degree of hardness. While it required 48 blows of a 10 lb. hammer dropping 30 in. to break a tooth out of gear B, it required 200 blows of the same hammer falling the same distance before a tooth could be broken out of gear A. This difference of only 50° lower quenching temperature resulted in 400 per cent increase in toughness. This example clearly illustrates that in order to get the maximum wear-resisting qualities in a drill bit, the quenching should be at the temperature at which the magnetism leaves the steel, and thus theory and practice both support the old rule that the lowest temperature that gives the desired results is the best temperature.

One of the conditions that works a hardship on the drill smith in the average drill shop is having to handle steel which contains varying percentages of carbon. Steel containing 0.90 per cent carbon does not require as high a temperature for hardening as a piece which contains 0.50 per cent carbon. If both steels were quenched at a temperature suitable for the higher carbon steel, the other steel, having a lower percentage of carbon, would be too soft. If the quenching temperature is raised high enough to secure the proper hardness of the 0.50 per cent carbon steel, and if the steel with the higher carbon content is quenched at this higher temperature, breakage and chipping of the bit is practically certain. This may cause the blacksmith a great deal of trouble, as in one section of the mine there may be a complaint about the steel being too soft, while other sections in the same mine will report the steel as being too hard.

Magnet Shows Critical Point.—Figure 2 shows an inexpensive electrical indicator for determining when the steel has reached the decalescent point. This is an ordinary horseshoe magnet hung from a fibre or other non-conducting support. At the upper end of the support is a copper contact for closing an ordinary light circuit. This indicator is more serviceable in the shop than an ordinary horseshoe magnet hung from a cord. When the heated bit is pressed against the copper plate the light will flash if the steel is at too low a temperature for quenching. The correct heat for quenching is when the magnetism leaves the steel. This indicator gives one of the two necessary facts about the temperature of the steel for quenching. It is the fact that the steel is hot enough, having passed the critical temperature.

Signalling Pyrometer Prevents Overheating.—The second fact that must be known is that the temperature is not too high. This can be assured by using an oil or gas furnace, the maximum temperature of which is indicated by a pyrometer. If the maximum temperature of the furnace is maintained at a predetermined point, there will be no danger of overheating the steel, irrespective of the time the steel remains in the furnace, within reasonable limits. In the past it has been the general practice to insert the drill bits into a raging hot furnace and depend on the watchfulness and skill of the operator to judge when the proper temperature has been reached. Naturally the results have varied with different men, different light conditions, and with the conglomeration of steel of several makes and various chemical compositions.

Quenching Liquids.—When the proper temperature is secured, quenching should be rapid. The object of quenching is to retain the characteristics which the proper heating has developed. The most satisfactory quenching medium for drill steel is circulating cold water. For uniform results the temperature of the water should be kept fairly constant. The effectiveness of water as a quenching medium falls off rapidly above 100° F. Brine solution is a faster quenching medium than water, but its effectiveness decreases with increased temperature, particularly above 150° F. It is difficult to maintain a brine solution at constant temperature, particularly where large quantities of steel are handled. Oil is used as a quenching medium where a high degree of hardness is not necessary.

Summary of Practice.—To summarize the suggestions here made that are fruitful of good results in applying theory to practice in the drill shop:

(1) The use of a coal or coke furnace should not be considered, as uniform results would be impossible.

(2) Oil, gas or electric furnaces are desirable, as close regulation of temperature can be had.

(3) Heating for both forging and tempering should be in a non-oxidizing furnace atmosphere. An oxidizing flame or furnace atmosphere causes scaling and decarbonization.

(4) An indirect or reflected heat is desirable.

(5) Forging the bits should be begun at a temperature above the critical point.

(6) The steel should not be allowed to "soak" in the furnace. "Soaking" increases coarseness of structure and decarburization of the outer surface.

(7) The coarseness of structure not only increases with increased temperature above the critical point but it also increases with the time during which it is held at the high temperature.

(8) The forging should stop at or just above the critical range. Working below the critical range or "cold working" induces internal strains. If the forging is stopped at a temperature above the critical range, the steel becomes coarse in structure again.

(9) Mechanical working or forging should be by vigorous, rapid hammering and not by squeezing or bulldozing.

(10) The more rapid the hammering is during the forging operation, the finer will be the resulting grain structure and the lower the teperature required for proper forging.

(11) The heating preceding quenching should be slow for uniform and proper distribution of heat throughout the mass of the bits.

(12) Maximum temperature in the tempering furnace should be only slightly above the critical temperature and kept at this temperature by pyrometer check.

(13) Each bit should be tested by a magnet to see that temperature is above the critical range.

(14) For hardening or quenching the lower the temperature is and still be above the critical range the better the results. Maximum density, hardness, and toughness are then secured.

(15) Quenching should be done quickly and on the rising heat.

Competition for Plans for Sewerage for French City.—An inter-allied competition for a plan for a sewerage system in Chauny, France, in which American sanitary engineers are especially invited to join, has been announced by the American Committee of La Renaissance des Cites. La Renaissance des Cites, whose president is M. Charles Dumont, reporter-general of the budget, and whose membership includes some of the leading engineers, architects, and other technical men in France, is the chief agency aiding the destroyed communities of the war zone in scientific planning and permanent rebuilding. It has helped with the plans of more than 200 towns, including Rheims, and is being assisted by the American committee in rebuilding Pinon as a demonstration of the possibilities of city planning for the benefit of the entire war area. From the competition for Chauny's sewerage system, La Renaissance des Cites hopes to develop ideas which will be useful in many manufacturing towns of medium size. The first prize in the contest is 10,000 francs and the second 5,000. The time limit for submitting plans is June 10, 1921. The sketches and other documents needed by contestants may be obtained from the French headquarters of La Renaissance des Cites, 23 rue Louis-le-Grand, Paris, France, for 65 francs ($4.55 at present rates of exchange), of which 50 francs will be returned when the documents are sent back. Further details may be obtained from the American committee, whose headquarters are at 248 Boylston St., Boston, Mass.

Methods of Providing Mechanical Protection for Piles

In an appendix to its annual report in Bulletin 233, the Committee on Wood Preservation, of the American Railway Engineering Association, has presented a resumé of the various methods for giving mechanical protection to piles in addition to creosoting them in the ordinary manner. It has long been recognized that creosoting, while an excellent process to prevent decay, and well worth while as a deterrent against marine borers, is not a sure or long-lived preventative in the worse infested water of the southern coasts. The following is taken from the committee's report:

Cast Iron Cases.—These cases have been used at points on the Gulf for many years. The cast sections are made in halves so that they can be placed in position after the piles have been driven and capped. As the castings are bolted together the casing is lowered to the mud line and forced down into the mud. The space between the case and pile is usually filled with sand and capped with cement mortar to prevent the sand being washed out by the waves. This protection is entirely efficient as long as the jacket remains intact. Cast iron corrodes very slowly in sea water and if made thick enough will resist corrosion a great many years. Some of these cases at points on the Gulf have been in position about 30 years. Care must be observed that the cases go far enough into the mud so that the piles will not be uncovered by the washing away of the mud, or by dredging operation. In this event the sand escapes and the entire pile is exposed to a current of sea water and then to attack by the borers.

At present prices of cast iron these cases are almost prohibitive in cost.

Vitrified Pipe Cases.—In locations not exposed to wave action and the pounding of drift vitrified pipe can be substituted for cast iron. It does not corrode, but is easily broken.

The pipe sections are preferably in one piece and placed over the pile before it is capped. The sections are cemented together, lowered to the bottom and forced into the mud. The space between the case and the pile is filled with sand and capped with cement mortar.

This protection has been much used along the Gulf and Pacific Coast, where full length protection is necessary, and is entirely efficient as long as it remains intact. Any defects in the case below the water will be shown by the escaping sand and any broken pipe sections can be easily replaced. It is the custom in maintaining these cases to make inspections and repairs about once a year. The borers will not have gained sufficient headway in creosoted timber in that length of time to cause trouble.

For protecting piles after they have been capped, or for making renewals, the pipe sections are made in halves and are joined together with some form of lock or copper wire, or treated wooden plugs.

Reinforced Concrete Cases.—Cases less fragile than vitrified pipe and less expensive than cast iron can be made of reinforced concrete.

The sections can be made in one piece for placing before the pile is capped, or in halves for placing afterward. One of the designs provides for a lock by leaving some of the reinforcing wires projecting so that they can be twisted together and covered with cement mortar after the halves have been joined. For these cases the concrete casing over the reinforcement is rather thin, and there is some question whether the reinforcement will corrode and the cases go to pieces under the action of sea water. Service tests are needed to develop this point.

The above methods afford full length protection, which can be placed at any time after the piles have been driven.

Concrete Jackets Cast in Place.—Considerable protection work has been done of late in Charleston, S. C., waters by casting concrete jackets in place about the piles. In these waters the teredo is less active than at points on the Gulf, and is successfully controlled by careful creosoting. The limnoria is very active and will finally cut off creosoted piles at about low water mark. It does not seem to work progressively on treated piles at depth greater than 2 ft. below low water mark, although piles that have been pulled show traces of attack in isolated patches all the way to the mud line. Under these conditions jackets of a length of about 10 ft., extending from about [illegible] ft. below low water to about 2 ft. above high water, is efficient. Some of these jackets are plain concrete and some are reinforced.

The reinforced jackets have been applied as follows:

Six-penny nails were driven into the piles in rings, the nails being about 6 in. apart, and the rings about 18 in. apart. They were left projecting about 3 in. and extended the length of the jacket. The reinforcement was No. 10 gage iron wire and was twisted around the nails. It was placed in two directions, both along and around the pile, and located about 1½ in. from the pile. The form was of ¼-in. wood veneering placed around the piles, resting against the heads of the nails and bound with wire. This veneering came in lengths of about 4 ft. and when one length was filled with concrete another was added and the jacket carried to the top. The form stretched sufficiently to allow the mortar in most cases to cover the heads of the nails. 1:2:4 concrete was used with ¾-in. stone. No great difficulty was found in placing the concrete. Most of the jackets were on piles exposed to the mud at low water, and the jackets were carried down to and into the mud. Where the water was deep the forms were carried about 3 ft. below low water, and bagging placed about the bottom to keep the mortar from running out. This feature is very important, for unless the bottom of the form is carefully stopped, the mortar will leak out and a failure will result.

A lot of these jackets were placed in 1915 and have not shown any sign of failure, except in a few cases the concrete has broken away at the bottom—due possibly to a leaky stop for signs of corrosion in the reinforcement, but no corrosion has been evident. The work of protecting piles in deep water should be performed in warm weather, as it is necessary for the workman to be working in the water much of the time.

Casting the concrete jacket in place has the advantage of restoring in a measure the strength of the pile, even though its section may have been reduced materially.

When it is necessary to work around bracing attached to the piles the advantage of the use of the veneering for the form is considerable, as it can be easily cut to fit the obstructions. Where there is much pounding from drift or bending in the piles, or if it is desired to strengthen as well as to protect them, the jackets should probably be reinforced, but it is certain that if the reinforcement can be omitted the work can be done much cheaper and generally better concrete will be obtained.

On a protecting job now going on in Charleston jackets of plain concrete are being used. These are about 3 in. thick and the concrete is 1:2:4 mix with fine aggregate. The forms are No. 24 gage galvanized iron, the sheet being wide enough to form a complete section. The two edges are nailed to wooden strips about 2½ in. square, one of which has a tongue and the other a groove. The sheets are placed around the pile and the wooden strips clamped together. A tight, smooth concrete form is obtained. These forms are made in different sizes and lengths to fit the different sized piles and different depths of water. By using forms made in this way concrete jackets have been carried as much as 12 feet below low water, and it was evident when examined by a diver that good results had been obtained. The general experience is, however, that it is not safe to trust to concrete that is deposited in more than 3 or 4 ft. of water.

When it is possible to pump out the form good concrete can be placed at greater depths.

Gunite.—In 1919, near Seattle, Washington, a large number of piles were coated with gunite. The committee has this work under observation, but it is too soon to report on the success of this particular job.

If the gunite coating proves durable it possesses certain advantages, as it can be quickly applied and should be comparatively cheap.

Nails.—The oldest method of protection of which we have knowledge is studding the exposed surface with nail heads. This was practiced by the Romans to protect against the teredo and the method has been used in European waters for centuries.

Its virtue does not seem to lie entirely in covering the exposed surface with nail heads, but is still effective when not more than one-fourth the surface is covered by the heads.

Several plain piles studded with nails were driven about 2½ years ago in Charleston harbor. The nails have heads about ¼ in. in diameter and are driven ½ in. to ¾ in. apart. The piles are entirely free from attacks by borers, whereas a plain pile without the nails driven at the same time has been reduced at low water line by the action of the limnoria from about 10 in. to about 5 in. in diameter.

Some tests of these nails have been made by the New York Dock Department, but it seems that elsewhere this method has not received the attention and study it deserves, and the committee suggests that the association arrange to have some service tests made. It is anticipated, however, that the work of applying the protection would be found rather expensive.

Sheet Metal.—Sheets of copper and zinc have been used with success in many places for protection against marine borers. This protection is entirely efficient as long as it remains intact. However, full length protection must be applied before the pile is driven and it is likely to be broken in handling. Copper is not affected by salt water, but zinc soon corrodes. It is stated that some of the brands of rust-resisting sheet iron will withstand the action of sea water for several years, and it is possible that that material could be used to advantage under some conditions rather than copper, which is too expensive.

Coatings of Tar, Asphalt, etc.—Many attempts have been made to provide a durable protection by applying coatings of tar or asphalt either alone or combined with some fabrics. These coatings are efficient as long as they can be kept intact, but they are likely to be broken by handling, or by the pounding of drift, and they have in general proved unreliable.

Bark.—Bark left on piles will protect marine borers, therefore, when plain piles are used in infested waters their life can generally be strengthened by leaving the bark on.

Leather Mats for Cold Car Floors

After considerable study and experimenting, the Chicago Elevated Railways have adopted leather matting to overcome the objection made to their composition car floors. Many complaints were received that these floors were cold. The following account of how this matting is used is taken from the Electric Railway Journal:

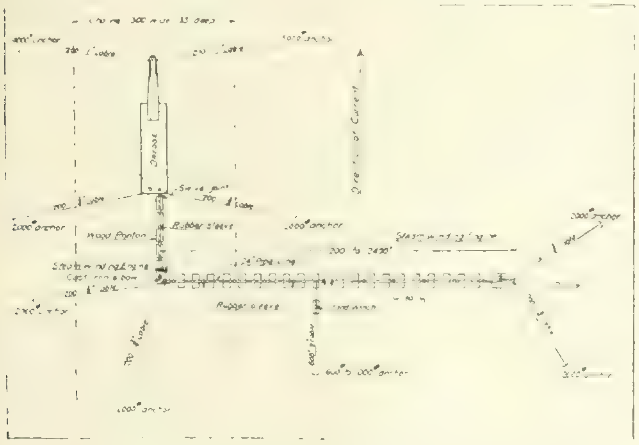
On cars equipped with longitudinal seats, the matting is used in a wide strip, extending from one bulkhead to the other and wide enough so that it reaches a few inches underneath the edge of the seat cushions so that a passenger's heels rest on it. In cars equipped with cross-seats, the mat is arranged to cover the aisle space between the seat pedestals, and additional pieces of matting, hinged to this main aisle strip, extend in between each seat. An arrangement of the matting for the longitudinal seats at the ends of these cars is made similar to that described for the all-longitudinal seat cars. In cars of both types of seating arrangement, the matting is laid down in three to five sections per car so that it may readily be rolled up and handled by one man. With the matting for the cross-seat cars, the pieces extending between the seats are simply folded over the aisle piece and rolled up with it to remove from the car. In order to prevent passengers from stumbling over the ends of the mat, which is about ⅝ in. thick, a wood strip beveled off was fastened to the floor at each bulkhead and the first section of the matting laid on the floor against this strip. No fastening whatever for the floor mat is required, as its flexible chain-link construction and weight makes it lie perfectly flat with apparently no tendency to get out of place. Not only is the leather a very good insulator of both heat and electricity, but it has the air space openings which improve the heat insulating properties and it has a very high anti-slip property. The advantages of the matting are particularly noticeable on wet, snowy days, for it provides a place for the water, snow and dirt to fall where it is not tramped in by passengers. Without the matting on such wet days, water accumulates into puddles on the composition flooring, sometimes clear into the center of the car, through which passengers must walk. The wearing qualities of the leather mat, inasmuch as it is made of leather punchings placed on edge, is thought to compare favorably from the experience thus far with that of the wood strips on the ordinary wooden car floor. The mats are used only during the winter months, and are stored for the eight warmer months so that this additional cleaning trouble and expense is encountered only four months of the year.

Method of Assembling and Handling Floating Pipe Lines in Dredging in Columbia River

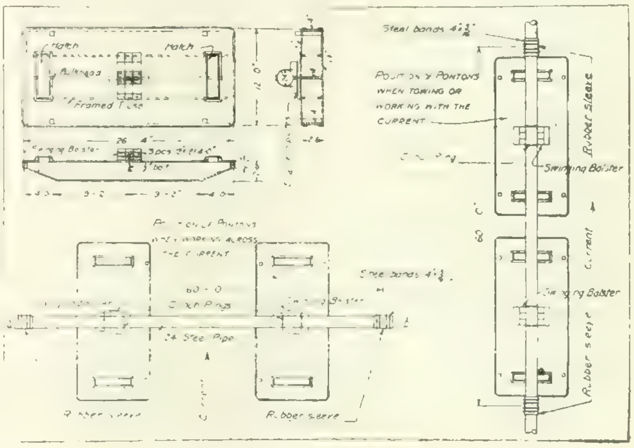
Methods of assembling and handling the ponton pipe lines of the U. S. Dredges "Multnomah" and "Wahkiakum," operating on the Columbia River below Portland, Ore., are described by Mr. R. E. Hickson, U. S. Assistant Engineer, in a recent issue of the Military Engineer. The matter following is taken from Mr. Hickson's article.

The floating pipe lines average about 1,800 ft. in length. They are made up of 60-ft. lengths of 24-in. lap welded steel pipe, supported on wooden pontons and connected with rubber sleeves.

The Pipe Line.—Sixty-foot lengths of pipe are used in order to reduce the number of sleeves, and for the reason that longer lengths supported on two pontons, one at each of the quarter points, make a steadier line without any vertical angles and give much better horizontal alignment, than shorter lengths each supported on a single ponton, as often used. In general, the sections of pipe should be as long as practicable consistent with ease in handling and size and number of pontons necessary for their support.



General Layout of Pipe Line and Anchors.



Plan of Ponton and Pipe Line Assembly.

No rivets are used in construction of the pipe, as these, even with countersunk heads, cause excessive wear at some points, and eventually will cause leaks and perhaps scrapping of the pipe before it has served the life possible if the wear were evenly distributed. The pipes are turned through about 120° every four or five months of service in order to distribute the wear. The end bands on the pipe used to hold the sleeves are bored to the outside diameter of the pipe for a depth of 1 in. They are slipped over the pipe and spot welded on the outside. The band is 3 in. wide and accordingly extends 2 in. beyond the end of the pipe, protecting the end of same until the outer 2 in. of the band has been worn away. The band is then cut off and a new one placed on the pipe. These ¼-in. pipes will last about six or seven seasons, or about 1,400 to 1,600 working days of 24 hours in the sand encountered in the Columbia River. The elbow used at the angle in the pipe line is made of cast iron with flanged ends, which are bolted to the adjacent sections of pipe, also fitted with flanges. Generally two 45° ells are bolted together to make a 90°, and these are generally taken from the interior of the dredge where they have served their safe life for hull piping. No new elbows are now bought for the ponton pipe line.

The Pontons.—The pontons used to support the pipe are built of Douglas fir lumber. They are little deck barges, 12 by 26 by 2½ ft. They are submerged about 13 in. with the pipe empty and 17 in. with the pipe full. The gunwale strakes and bulkhead are 4 in. thick, deck 2 in., and bottom 2½ in. Hatches are provided at each end to allow air to circulate through the ponton during fine weather, and canvas covers are used over these in stormy weather. In the center of the ponton is a swinging center or bolster, consisting of three pieces of 12 by 12 in. timber, 4 ft. long, bolted together, and cut out to a depth of 6 in. in a cylindrical recess to receive the 14-in. pipe. A 1½-in. kingpin passes through the center of this bolster and down into the longitudinal bulkhead below deck.

A 1½-in. king pin passes through the center of this bolster and down into the longitudinal bulkhead below deck. A ¼-in. steel plate is fastened on the bottom of the bolster and a similar plate on a raised bed on the deck of the ponton. These plates take the wear and reduce the friction between the swinging bolster and the bed on the deck. The pipe rests only on this bolster, and is fastened to it by means of two sets of curved straps ½ by 2 in., one set at each end of the bolster, connected and tightened with bolts at the top of the pipe. The ponton itself is free to be swung under the pipe into any position that may be desired. A walk and handline are fastened to the top of the pipe to aid men in walking the line during rough weather.

Handling the Pipe Lines.—In operation, these pipe lines are generally set up across the current and the pontons are set at right angles to the pipe line. If it is necessary to lay the pipe at any other angle with the current, the pontons are swung accordingly, and at times it may be necessary, in order to relieve the side pull on the dredge or anchor scow, to "cut" the pontons slightly into the current when they will act like the rudder boards on a shear boom, and thus place the greater strain on the anchor lines at the end of the pipe. When the pipe line is towed any distance, especially up stream, it is absolutely necessary that the pontons be lined up with the pipe as the surface velocities of the Columbia River vary from about 3 to 5 ft. per second, and it will be understood how difficult it would be to tow 1,500 to 2,000 ft. of pipe line against this current with all the pontons connected rigidly at right angles to the pipe, and if connected longitudinally, as is done with some dredges, it would be impracticable to hold the pipe line across the current when set up for operation. The bolster or swivel type of ponton overcomes these difficulties admirably.

The pipe line is held in place when in operation by means of anchors, two of which weighing 2,000 lb. each are placed beyond the end of the pipe line and are connected to a winding engine on a 22 by 56-ft. scow supporting the last length of pipe. Dead men on shore are often used instead of the anchors. At the elbow in the pipe line near the dredge two anchors are also connected. These two sets of anchors pulling in nearly opposite directions hold the pipe line in position. One or more smaller anchors are also used, when necessary, with hand winches to hold up the sag in the middle of the line. These winches are mounted on independent pontons, which can be shifted to any point in the line without disturbing the main pipe-line connections. Between the elbow in the pipe line and the dredge two lengths of pipe are generally used.

By using the anchors at the elbow in the pipe, nearly all the pull of the floating line is taken off of the dredge and much more satisfactory operation on channel work is possible than when the long pipe line leads directly from the dredge. Steam for the winding engines connected with the anchors is furnished by an upright boiler of 35 HP. on each of the scows. Slab or block wood is used as fuel for these boilers. The main anchor lines are ¾-in. cables, 1,000 or 1,200 ft. in length. The lines to the smaller anchors and hand winches are ½-in. cables about 600 ft. in length.

As the work progresses the anchor lines are gradually paid out and a tug equipped with a steam winch and derrick is used to shift the anchors. This is generally done once each day. When deep-draft steamers pass, the dredge is swung out to the edge of the cut and the anchor lines crossing the channel are slacked off and drop to the bottom while the steamer is passing. When the vessel has safely passed over the cables, the "donkey man" on the anchor scow hauls in the slack of the cable, and again tightens the pipe line into its proper position. The anchor lines at the end of the pipe line are generally not disturbed during the passing of a steamer, as the end of the pipe may be in shallow water or up against a bank or dump, and cannot be moved any farther away from the channel. The drawing herewith will show the general layout of the dredge, pipe line and anchors when set up for operation.

It has been observed that dredges are often operated with only small anchors holding the pipe in position, and that the pipe line is often quite slack. This results in excessive wear on rubber sleeves through the bumping or chafing of ends of the various sections of pipe and buckling of the sleeves. A large part of this trouble can be avoided by providing winding engines of sufficient power at the end of the pipe line to keep the slack out of the line. With lines over 1,000 ft. in length operating where there is any wind or current, good winding engines and heavy anchors are almost indispensable. In addition to saving rubber sleeves, a tight, straight pipe line offers less resistance to pumping than a slack line with numerous angles and sleeves buckled up to restrict the flow.

View of Pipe Line, Showing Swinging Bolster and Rope Jacket.

Life of Rubber Sleeves for Joints of Pipe Line.—Rubber sleeves are used every 60 ft. throughout the pipe line. These sleeves are 36 in. long and 25½ in. inside diameter. They are now manufactured under standard specifications of the Engineer Department for Class "A" sleeves. Since 1914, when the dredges Multnomah and Wakiakum were placed in commission, the average life of dredging sleeves has been 245 working days of 24 hours. The maximum life has been 739, and minimum 88 days. Some sleeves, broken through wrecks or unusual causes, have been eliminated from the averages. It has been found from the sleeve records of the dredges that the average life of the sleeves has been greater during the last two or three years than in the earlier periods of operation; for while the average life of all sleeves for both dredges has been 245 working days, the sleeves renewed during the last fiscal year had an average life of 272 days on the Multnomah and 365 days on the Wahkiakum. Two sleeves not included in the above averages were replaced on the Wahkiakum during the month of August, after serving 467 and 470 days, respectively. Both sleeves broke during a storm on account of kinks in the pipe line.

Rope Mat Protection for Rubber Sleeve.—The added life in the later records may be due to better quality of sleeves, but it is believed should be attributed also to the use of rope "mats" or "jackets," which have in recent years been placed around each sleeve, while in service, to take the strain from excessive pressures and prevent to a great extent the bulging of the sleeves, which often causes a rupture of the inner tube near the points where the pipes end. The "jackets" were installed first on the Wahkiakum, which it is believed accounts for the greater average life of the sleeves on that dredge.

These "jackets" are made up of 1-in. manila rope, woven in the form of a mat or net with length of meshes about 12 in., the meshes being fastened with a seizing of marlin (9 turns) instead of being knotted as in a net. The "jacket" is about 6 ft. long, and when placed around the sleeve the two ends are laced together. When the rope stretches, this lacing can be tightened up at any time the dredge is not pumping. About 100 ft. of rope is required to make a "jacket" for a 24-in. sleeve. The estimated cost is about $8 or $9 for materials and about 4 hours' time for one man, for which no charge should be made, as it is all in the day's work.

It is believed that this device adds 25 to 50 per cent to the life of the sleeves, although this would be difficult to prove. Use of the "jackets" is also advantageous in reducing the loss of head in the pipe line caused by enlargement of the pipe section at the joints. The sleeves purchased recently under the standard specifications of the department have not yet been in service a sufficient length of time to determine their life, but it is expected this will be considerably greater than the average of those previously used on account of the high tensile strength of duck and rubber now called for under the standard specifications.

The proper length of sleeve to use with a given diameter of pipe is a question which has not been definitely settled, but must probably be determined by the conditions to be met and by actual trial. With these dredges working under the conditions on the Columbia River, a 36-in. sleeve has been found most satisfactory, after trial of 30 to 32-in. lengths. The trials were not very exhaustive, however, and the experience of others in this matter would be of interest and value to the writer. The price of 36-in. sleeves for 24-in. pipe has advanced from $50 to $55 in 1913 to about $115 in 1920. Part of this increase is no doubt due to the more rigid specifications.

First Cost and Maintenance Cost of Pipe Line.—Cost of the pipe lines of the dredges in 1914 and 1920, and maintenance cost over this period, are shown in the following tables:

FIRST COST OF 60 FT. OF PIPE LINE

	1914.	1920.
60 feet 24 by ¼ in. lap-welded pipe	$360.00	$ 590.00
2 wooden pontons 12 by 26 by 2½ ft.	350.00	900.00
1 36-in. rubber sleeve, 25½ in. I. D.	55.00	115.00
1 rope jacket	5.00	9.00
60 feet walk handline, etc.	9.00	16.00
Total for 60 ft.	$779.00	$1,630.00
Total cost per foot	12.98	27.17

COST OF MAINTENANCE.

	Depreciation, per cent.	—Cost basis— 1914.	1920.
60 feet pipe	100	$ 360.00	$ 590.00
2 pontons	75	262.50	675.00
1 rubber sleeve	600	330.00	690.00
Miscellaneous repairs, etc.		100.00	200.00
Total		$1,052.50	$2,155.00
Maintenance cost per foot for 6 years		17.54	35.91
Maintenance cost per foot per annum		2.92	5.98

With steel pontons of the catamaran type at $1,600 per unit, with two units for each 60 ft. of pipe, the first cost of pipe line per foot in 1920 would become $65.50, and if steel, flexible joints were also used in place of rubber sleeves, the cost would be about $71.77 per foot of pipe line.

Comparison of Wooden and Steel Pontons.—A comparison of the cost of wooden pontons as used here, with those constructed of steel, considering the life of the two plants, shows a decided economic advantage in the wooden plant. Based on a life of 8 years for wooden plant and 40 years for steel, the following comparison of cost of a single ponton unit is drawn:

Estimated first cost of wooden ponton	$ 450.00	
Estimated first cost of steel ponton, catamaran type	1,600.00	
For a period of 8 years:		
	Wood.	Steel.
Interest on first cost at 5 per cent per annum	$180.00	$640.00
Depreciation for 8 years	450.00	320.00
Repairs, etc.	50.00	20.00
Total	$680.00	$980.00
Saving in a wooden ponton in 8 years		300.00

The cost of repairs to wooden pontons given above does not include minor repairs made from time to time by the crew while the plant is in operation, as these are made during spare time of the crew, who are necessary in any event for handling the plant, and no extra labor cost is involved. The value of materials used is small. The only real repairs made on these pontons has consisted in lifting them out on a dock with a derrick, setting up the caulking on the rakes and repitching the decks. The cost was less than $50 each.

In the above estimates the life of wooden pontons is given at 8 years. It is known, however, that this is practically a minimum, and that with careful selection of seasoned lumber, can be materially increased. Investigations are now being made as to the probable cost of construction, using creosoted lumber, indications being that the life of wooden plant will be thereby increased 50 per cent to 100 per cent, or more, depending on the treatment, at a comparatively small additional cost.

Method of Preventing Slides in Clay Soil in Railway Cut

An interesting scheme for conquering slide troubles at a railway tunnel portal was described in a committee report submitted at the recent convention of the American Railway Engineering Association. The work was done on a western railroad at a tunnel about 1¼ mile long, where the cut slopes sloughed in and blocked the portal cut with material, which was of the consistency of thick mortar. This trouble usually occurred in the spring, coincident with melting snow and thawing ground. The water, despite several surface ditches, had reached the cut slope in sufficient quantities to thoroughly saturate the clay, which is of several varieties and mixed with soft soapy rock in a shaly formation. The upper formation is mostly a bright yellow clay, shading off lower down to a very tough red clay. Seams run through this formation in all conceivable directions, and this gives the water an opportunity to thoroughly saturate the mass, and in this condition the clay loses all cohesive properties.

All ordinary methods to prevent this slide trouble were tried. Several lines of drain tile and French drains were constructed, only to become filled and choked with silt in a short time; rows of piling were driven near the lower edge of the cut, framed together, and a system of bracing extended to other rows of piling driven about half way up the side of the cut. This pile protection was put in where the first slide occurred, but subsequent slides went through and around it and carried some of it down to the track. Another slide occurred a short distance east of this pile bracing after the material from the first slide had been removed, and it was then necessary to devise some other methods to conquer the slide trouble. It was finally decided to construct a system of drainage tunnels, supplemented by a series of ditches filled with clay and then burned.

A 12-in. drain tile had been originally installed along the foot of the cut slope to drain the railroad tunnel, including a spring that had developed during the first slide. This drain tile now serves to carry off the additional water from the drainage tunnels and trenches mentioned. Three trenches were dug parallel with the track, and six cross trenches, approximately at right angles. The average depth of the parallel trench nearest the track is about 5 ft. The other parallel trenches and the cross trenches have depths of over 20 ft., in the deeper parts of the cut. The bottoms of these trenches are cut to a grade line, which leads toward the track.

After the trenches were excavated, they were refilled with kindling, scrap ties, coal and clay, the layer of fuel being about 2½ ft. thick, with next a layer of clay about 2 ft. thick, and alternately placed to fill the trenches and tunnels. Chimneys of 6-in. tile to afford proper draft were placed a short distance apart. Care had to be used in regulating the draft, so as to keep an even fire, and thereby insure a thorough baking of the layers of clay and sides of the trenches. As the fuel burned out and the clay subsided in the trenches, more clay was put on top; and the surface thereby restored. The object sought was to get trenches and cross-trenches filled with semi-vitrified clay; also to thoroughly bake and stabilize the surrounding material. Through this mass of baked material, the water readily finds its way to the tile drains along the track.

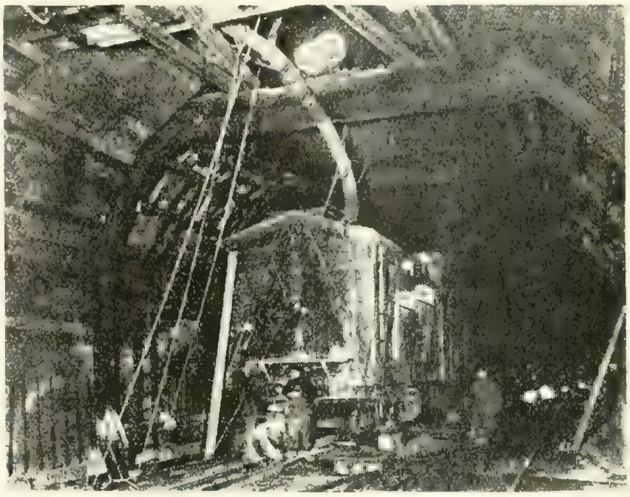
In addition to the above-named trenches, three drainage tunnels were driven back into the bank, a little below the grade of the track; tunnel No. 1 was driven 102 ft.; No. 2, 120 ft.; and No. 3, 142 ft. Then tunnels 2 and 3 were connected at the inner ends by a tunnel running parallel with the track, the grades being about 0.6 of 1 per cent. The tunnels were built rectangular in section, 4 ft. wide by 6½ ft. high, so as to work in them with wheelbarrows and shored and braced with timber, similar to mine work.

The inner ends of these tunnels were 35 ft. and 40 ft. underground, and tapped the springs of water in the bank beneath the system of trenches described above. This method of drainage has proved to be very efficient in this location, as no further slides have occurred in about 10 years' time.

Method of Lining the Connaught Tunnel of Canadian Pacific Ry.

Work is under way in connection with completing the concrete lining of the 5-mile, double-track, Canadian Pacific Ry. tunnel at Glacier, B. C. We are indebted to The Contract Record for the following details regarding this work:

This longest mountain railway tunnel on the continent was driven but a few years ago and has yet about 17,000 ft. unlined. The tunnel is at an altitude of about 4,000 ft. above sea level and is located in the heart of the Selkirk Mountains, making working conditions, therefore, somewhat difficult. The snow fall in winter is very heavy—about 40 ft., and the distance to the nearest city where supplies may be obtained is 220 miles.



Concrete Mixing and Placing Plant.

The plant for lining the tunnel was designed with special consideration to safety, non-interference with railway operation through the tunnel, non-interference with signal and other circuits, fire hazard, reasonable and economic speed in performance and special weather conditions in the mountains.

The Electric Power Plant.—The main item in the construction plant for the lining work consists of an electric power plant which it was decided to construct to supply power sufficient for the brilliant lighting of the working zones within the tunnel and for the operation of a plant mounted on cars, consisting of air compressor with its operating motor and auxiliary apparatus, storage space for the materials for the aggregate, and motor operated mechanical pre-mixing and air-placing concrete apparatus. A transmission line to the working zones, transformers, low tension lines to the lights and motors, and a gasoline locomotive for hauling this plant and the supply cars are necessary adjuncts of the plan.

The power plant, which is of 300 k.w. nominal generating capacity, is located near the west portal of the tunnel, but on account of the topography it was not feasible to place the power plant at main line level, and it was therefore located on an embankment south of the railroad. A high line with a switchboard permits the delivery of coal in carload lots, while water is made available both from a gravity camp supply and from the Illecillewaet river, which flows by the power house.

The power house is constructed of frame on concrete foundations and is fitted with three old locomotive boilers, equipped with forced draft blowers, separate stacks and breeching. There are two generating units, each of 150 k.w. nominal capacity, driven by direct connected, simple, horizontal, non-condensing engines. The units may be run separately or in parallel.

Illumination of Working Sections Under Smoke Conditions.—Careful consideration was given to a variety of schemes for illuminating the working sections under smoke conditions and at the same time [illegible] illuminating the work after the smoke had cleared. [illegible] laboratory experiments were made and flood lights [illegible] capacity each were finally decided upon. The [illegible] portable and adjustable as to diffusion of beam, and have been found to work out in practice exceedingly well, permitting illumination to be varied immediately to meet [illegible] particular set of conditions obtaining in the tunnel at any time. They also have largely cut the time lost due to smoke and show a large saving in labor costs.

Pneumatic Concrete Placing Apparatus.—The concrete mixing and placing apparatus consists of two 75-ton pit flat cars coupled together. On one car there is located a 1,300 ft. motor-driven compressor while on the other car is an electrically driven concrete mixer of 22 yd. per hour capacity and a pneumatic concrete placing apparatus. Storage bins for sand and gravel are provided on each car with a belt conveyor to carry material from one car to the other. Cement storage is located convenient to the mixer and the necessary water tanks are provided. All storage is calculated on the basis of blowing a complete form without coming out of the tunnel to recharge. Sand and gravel are delivered to the mixer skip by gravity and the mixed concrete drops by gravity into the air placer.

In operation the cars are spotted near the form to be blown and are connected to the electric power line through the nearest outlet from it. Concrete is led through pipe and flexible hose connections into the form under about 80 lb. air pressure.

The Forms.—The forms consist of six separate units of the Blaw Knox collapsible pattern, each form providing about 20 ft. of finished tunnel lining at one placement. They clear all traffic and are on wheels so that after the concrete is blown and set, the top plates can be collapsed and the form rolled forward to its new position. A substantial movable platform precedes each concrete form and is used for doing the necessary advance work, which consists in general of fastening false forms to the tunnel roof where the tunnel section is overbroken, in packing slab wood lagging back of the false forms, in placing reinforcing steel and in scaling rock. These advance forms clear all traffic and are built up of light steel and timber frame work. There are six of them altogether, each holding considerable amounts of construction material as well as the workmen.

Gasoline Locomotive Handles Mixer and Material Cars.—A 27-ton gasoline locomotive is part of the plant. Its duties are varied and include the handling of the mixer cars in and out of the tunnel, the handling of rock scaling and derrick cars, material cars, switching of cars in the yard and to the high line, switching of material cars to the storage sheds, running of lunch cars into the tunnel in order to save working time otherwise consumed by the men going out for lunch, and in general the many miscellaneous switching uses continually arising on work of this kind. The machine is rated to handle 210 tons on a 1 per cent grade and is operated by one man. An electric locomotive would have imposed excessive costs and a steam locomotive would have aggravated smoke conditions in the tunnel. The effect of the exhaust gases from the gasoline locomotive was carefully considered, but found to be negligible.

Production of Explosives in the United States.—For the past seven years the Bureau of Mines has undertaken the compilation of annual reports showing the production of explosives, excluding exports, in the United States.

The following statistics, received from manufacturers, show the production of explosives in the United States from 1912 to 1919:

Year.	Lb.
1912	489,493,131
1913	500,011,845
1914	450,251,489
1915	460,900,796
1916	505,415,052
1917	582,475,327
1918	499,224,660

This production was of explosives used for domestic purposes only, and does not include the amounts manufactured for export by the various powder companies nor the munitions of war or explosives manufactured by the government during the war.

A Plea for Improvements in Maintenance Accounting

Mr. C. A. Morse, chief engineer, Chicago, Rock Island and Pacific Railway Co., points out some of the important reasons for a revision of railway maintenance accounting in a brief article which is here reprinted in full from the Railway Age of March 15, 1921.

Under the Transportation act the railroads are divided into certain groups which are permitted to charge a rate that will return for the group as a whole 6 per cent interest on the value of the railroads in that group. Consequently, it would seem as though it was going to be necessary for the railroads in each group to follow, as far as possible, the same practice in regard to maintenance, and that it is going to be necessary to follow some classification as to the importance of different portions of each railroad so that all the railroads in a group will maintain the portions of the road under each classification in practically the same way.

Following this line of thought, it would seem as though wages and working conditions should be the same on all the railroads in a group. It also appears desirable, if not absolutely necessary, to have some plan worked out by which the expenditures for different items included in maintenance could be classified, so that the expenditures of all roads in a group would be accounted for in the same manner. This would enable comparisons to be made not only between the different railroads but between different portions of the same railroad, in order to awaken interest in the most economical methods for handling the various classes of work.

Maintenance of way and structures comprises about 20 per cent of the total operating expenses, and it is the only portion of the operating expenses that is not analyzed in such a way as to give comparative costs as between operating divisions and between different railroads. The only basis of comparison today is the cost of maintenance of way per track mile and the cost per 1,000 gross ton miles, which is of little value, owing to the fact that the operating expenses due to improvements and retirements are included in the general item of maintenance of way and structures, and the division or railroad that has a big improvement program under way shows large maintenance of way expenses as compared with the division or railroad that happens to have little improvement work in progress at the time.

If what may be termed ordinary maintenance was kept separate from maintenance in connection with the "A. & B." program, and from the items covering rail relaying, ballasting and the tie renewal programs, and if retirements could be set up separately we would be able to make proper comparisons of: A—Ordinary Maintenance, B—Tie Renewals, C—Ballasting, D—Relaying of Rail, E—Retirements. These could be made per mile of operated line or per 1,000 gross ton miles, but the real comparison would be for ordinary maintenance, which should include all of the work of the regular maintenance of way organization, both labor and material.

One of the weak points in the present accounting rules is that which calls for contract work to be charged to material. There is no reason why it should not be divided into labor and material the same as company work. Altogether too much money is spent under the name of material, which is not properly supervised, owing to the fact that on many railroads the allowances only cover labor, the material being figured as a certain percentage of the labor charge. By doing certain work by contract local officers get a lot of work done which they could not otherwise get done and keep inside of their allowance.

While it does not seem as though this close supervision should be necessary, much expense is needlessly incurred in the maintenance of way department of railroads, due to personal equation in the local organization and an ambition to get the individual divisions or territory in as good condition as possible, regardless of the requirements of some other part of the railroad.

The American Railway Engineering Association with its splendid organization should be able to go into this matter and recommend a classification of tracks and also a set of accounting forms that would give the results outlined above.

Comparative Costs of Tunnel Driving 1916-1920

Comparative costs for a 5-year period of driving the Spiro drainage and transportation tunnel are given by Mr. Harry A. Lee in an article in the April 2 Engineering and Mining Journal, from which the data following are taken:

The Spiro tunnel of the Silver King Consolidated Mining Co. of Utah, is situated near Park City, Utah.

Work was started during the summer of 1916, and has been continuously prosecuted since that time. The breast is now 14,400 ft. from the portal. The period of time comprised in this review is four years, extending from July 1, 1916, to July 1, 1920, and the length of bore considered is 12,944 ft.

The Spiro tunnel starts at the base of the mountain and is driven on a tangent, with a grade of 0.3 per cent. Starting in the limestones of the Thaynes formation, it passes into the Woodside shale, Park City limestones, and the Weber quartzite, in the order named. These formations have an average dip of 25°, and the bore cuts the beddings at an acute angle.

A shift's work in the heading consists of drilling and firing a round. In the 12,944 ft. no rock was encountered in which a round could not be completed in an 8-hour shift by competent machine-drill men. The material and labor demand for each round and each foot of progress was constant, the only exceptions being when in soft or swelling ground that required timbering close up to the breast following each blast before it was practicable or safe to start the next round and when the haul was longer.

The machine drills were operated under 100-lb. pressure. Each machine man has his own drill, and following each shift the drill was trucked out, cleaned, oiled, tested, and, if necessary, repaired. This method insured a machine that worked perfectly when placed on the bar and obviated the claim so commonly made that the man on the previous shift had left a "bum" drill. It also proved a big saving in drill repairs.

The average sizes of timber used were: Sills, 6x10; legs, 8x8; caps, 8x10; and lagging, 2-in. rough. These sizes were varied somewhat to suit heavy or swelling ground. The sets were placed 5 ft. from center to center on the average, and where timber sets were not required the sills were placed on grade at 5 ft. centers and hitched into the walls for the entire distance.

The surface plant is modern, with a well-equipped blacksmith shop, a machine shop, a carpenter shop, a change room, magazines, and adequate storage rooms.

Costs of labor and material for the 5-year period 1916 to 1920 are given by years in accompanying tables.

The tables do not take into consideration the initial cost and equipment of plant, depreciation, taxes, legal expense, fire insurance, office expense, or administration. The daily wage is the average of all employees, both underground and upon surface, including bonuses, average for the year from monthly and semi-monthly payrolls. The figures illustrate plainly the effect of increased cost for material and labor and the inefficiency of labor; also that an increase in wages produced no improvement in results.

By reason of the fact that a shift's work per man was practically fixed at the Spiro tunnel, and that the same wage could be had at other properties in the district, wherein a shift's work could not well be measured, it is possible that the inefficiency of labor at other properties may not have been so marked. Conditions have been improving, but normal routine is still to be achieved.

DETAILS OF SPIRO TUNNEL FOR 12,944 FT.

Location—Park City, Utah.
Purpose—Development, drainage, transportation
Character of rock penetrated—Limestone, shale, quartzite
Size broken—8x9 ft.; ditch on side, 3x4 ft.
Cross section—84 sq. ft.
Grade—3 ft. rise in 1,000 ft.
Power—Purchased electric current.
Air pressure—100 lb., generated by electrically driven compressor.
Air line—4-in. O. D. casing.
Ventilator pipe—18-in. steel, dipped.
Water line to drills—1½-in. black pipe.
Drills—Pneumatic hammer.
Drill mounting—Horizontal bar.
Explosives—50 per cent gelatine dynamite in cuts; 35 per cent in sides.
Number of holes per round—16 to 24.
Average depth drilled—5 to 8 ft.
Cars—20 cu. ft., roller bearing.
Type of haulage—Horse.
Track of switches—30-lb. rail, 18-in. gage.

TABLE III—COMBINED LABOR AND MATERIAL COSTS.

	Cost per foot					Per cent increase over 1916			
Labor ...	$8.157	$16.032	$17.978	$21.947	$22.975	96.0	120.0	169.0	182.0
Material.	7.912	10.384	12.09	15.089	17.08	31.2	52.8	90.7	128.5
Totals	$16.07	$26.42	$30.07	$37.03	$40.06	.....	.....	.....	.....
Averages						64.4	87.1	130.4	149.3

Cost of Railroad Electrification.—In a discussion of a paper presented before the Electrical Section of the Franklin Institute at Philadelphia, Mr. A. H. Armstrong of the General-Electric Co., stated that the original 440-mile electrification on the Chicago, Milwaukee & St. Paul cost about $13,000,000. This included 42 freight and passenger and two switching locomotives. This, he said, figures out at about $28,000 per route-mile or $18,000 to $19,000 per single-track mile. The freight and passenger locomotive cost about $130,000 each, and they replaced 112 steam locomotives, worth about the same in total as the electrics; hence the items of locomotive costs about offset each other. The last 220-mile electrification on this road cost more, having been carried out in war time, the increase being, roughly, about 50 per cent.

TABLE I—LABOR COST.

					Increased Cost Due to		
Year.	Feet progress of tunnel.	Average wage* per shift.	Cost per ft. (average).	Increased cost per foot over 1916, per cent.	Wage increase, per cent.	Additional timber haulage, ditch work, rubber bonus and compensation insurance, per cent.	Labor inefficiency, per cent.
1916	1,461	$3.857	$ 8.157	Base	.....	....	.....
1917	3,539	4.294	16.0315	96	11.30	17.0	67.70
1918	4,001	5.006	17.9782	120	29.79	14.25	75.96
1919	2,622	5.403	21.9475	169	40.08	25.20	103.72
1920	1,321	5.757	22.975	182	49.27	33.20	99.53
	12,944		$17.65				

*Average wage per shift paid underground and surface employes.

TABLE II—MATERIAL COSTS.

Article	Cost per foot 1916.	1917	1918.	1919	1920	Per cent increase over 1916 1917	1918.	1919.	1920.
Explosives	$2.547	$3.54	$4.501	$5.27	$5.537	38.83	75.50	106.70	116.90
30-lb. T-rail (complete)	.41	.517	.749	.73	..43	27.0	83.0	79.0	78.1
4-in. O. D. casing and 1½-in. iron pipe	.332	.46	.63	.80	.806	38.6	89.8	141.6	142.8
18-in. steel vent and pipe	.95	1.25	1.67	1.60	1.75	31.6	75.8	68.5	84.3
Machine drills, repairs and couplings	.58	.75	.79	1.19	1.50	29.4	36.3	105.2	158.7
Timber (per ft. timbered)	1.71	1.74	2.14	2.589	2.20	1.8	25.2	51.2	28.7
Electric power	1.56	1.099	1.26	1.061	2.16	*30.2	*19.3	25.7	38.5
Drill steel	.245	.489	.308	.47	.75	101.2	29.2	96.0	212.5
Illuminants	.09	.241	.179	.26	.288	166.0	100.0	188.0	210.0
Tools, electrical supplies and general hardware	.158	.094	.133	.38	.363	*43.7	*18.7	137.0	125.0
Lubricants	.35	.038	.064	.135	.187	33.0	100.0	333.0	500.0
Horse feed, shoeing, etc.	.117	.251	.46	.886	1.305	108.0	283.0	633.0	990.0
General repairs and plant maintenance	.07	.14	.236	.30	.379	92.0	223.0	311.0	419.0
Coal and coke	.02	.13	.131	.274	.38	550.0	550.0	1,350.0	1,900.0
Averages	$7.912	$10.384	$12.09	$15.089	$17.08	31.2	52.8	90.7	128.5

*Denotes decrease.

Analysis of Grading Quantities and Costs on New England Railroads

From the Railway Age we quote the following data and tables. They were prepared by a committee representing the New England railroads, as a part of a report which had for its aim the determination of the cost of reproduction as of the year 1914.

The investigation covered the moving of over 34,000,000 cu. yd. of excavation from bank to fill, exclusive of work on the Southern New England R. R. This represents all of the work of any magnitude which has been done between 1880 to 1915 in the territory covered by the New England railroads. The results obtained from the data and the diagrams confirm what is a matter of common knowledge, that is, that the costs between 1896 and 1900 were low and that from 1900 to 1915 they have increased.

The section of country represented consists topographically of a comparatively narrow coastal plain backed by foothills which become mountainous over a considerable portion of New Hampshire, Vermont, northwestern Connecticut and western Massachusetts. The coast line is very irregular, being broken by rocky headlands and indented by tidal estuaries with deep deposits of silt, causing heavy subsidence and difficulty in depositing fills.

The rock is largely volcanic, generally granite and conglomerates. Slate predominates locally in some sections of Maine, Vermont and eastern New York, marble in parts of Connecticut, Massachusetts and lower Vermont and sandstone with fissures filled with trap rock in the Connecticut valley south of the Massachusetts-Vermont line. The rock as a rule is hard to drill and difficult to handle. It generally occurs in small quantities, in saddles and pinnacles covered by an overburden of earth of irregular depth. For this reason the grade line of the New England railways has usually been kept high and the deficiency made up from borrow.

Many of the hills are full of springs and the rainfall and snowfall are heavy. These springs usually make trouble where the rock lies in pinnacles and saddles or where an impervious clay underlies the sand or gravel, and frequently require pumping, especially where the cut runs with the grade. In many cuts the common excavation approaches hard pan.

The prices shown in the accompanying tables were all figured on the "one way" basis, that is, on a single price from cut to fill. At first it was attempted to work out the grading on the basis of the contract price without the overhaul and to determine separately a price for overhaul. It was found, however, that not only was there no consistency between the methods adopted by the Bureau of Valuation and the practices of the various carriers, but that no continuous plan had been followed in the case of the individual carriers for any considerable number of years.

As a result of this condition, the only common basis to which all the data could be brought was "cost in place" including haul.

WEIGHTED AVERAGE PRICES FOR FIVE-YEAR PERIODS WITH OVERHAUL, EXCAVATION—COMMON—ROADWAY, YARDS AND TERMINALS.

	Contract price.			Quantity Sum—5-yr. periods	W.A.P. 5-yr. periods.	Amounts Sum—5-yr. periods.	Year to which W.A.P. applies.
Yr	Quantity.	Price.	Amount				
1890	172,546	$0.281	$48,476.78	806,894	$0.308	$248,826.26	1888
1891	95,976	.282	27,076.55	902,850	.306	275,902.61	1889
1892	336,333	.352	118,251.96	1,066,109	.307	327,415.35	1890
1893	94,164	.311	29,588.41	923,526	.313	289,093.87	1891
1894	241,717	.366	88,521.51	940,736	.332	311,915.01	1892
1895	962,112	.312	300,481.89	173,302	.326	563,920.12	1893
1896	984,017	.239	235,359.10	2,618,343	.295	772,202.87	1894
1897	636,740	.396	253,277.28	2,918,750	.311	907,228.19	1895
1898	4,772	.233	1,110.60	2,829,358	.311	878,750.38	1896
1899	532,043	.230	122,214.76	3,119,684	.292	912,443.63	1897
1900	....	....	....	2,157,572	.284	611,961.74	1898
1301	215,131	.198	42,639.31	1,388,686	.302	419,241.95	1899
1902	242,801	.240	58,272.96	994,750	.225	224,237.63	1900
1903	142,605	.211	30,019.92	1,132,583	.224	253,146.95	1901
1904	106,983	.286	115,571.10	1,097,523	.245	246,506.59	1902
1905	527,427	.384	202,715.76	1,534,950	.292	449,222.35	1903
1906	569,471	.286	162,624.22	1,889,290	.301	569,207.26	1904
1907	....	....	....	1,646,186	.31	510,934.30	1905
1908	....	....	....	1,503,881	.32	480,914.38	1906
1909	3,455	.380	1,312.90	1,100,353	.333	366,652.88	1907
1910	288,927	.396	113,055.36	861,853	.321	276,992.48	1908

WEIGHTED AVERAGE PRICES FOR 5 YEAR PERIOD ON ALL NEW ENGLAND ROADS—EXCAVATION—COMMON—ROADWAY, YARDS AND TERMINALS—INCLUDING OVERHAUL.

	Totals by years.			Totals by 5-year periods.			Year to apply W.A.F.
Year.	Quantity.	Amount.	W.A. price.	Quantity.	Amount.	W.A. price.	
1890	288,415	$82,353.31	$0.286	3,365,805	$1,041,967.59	$0.310	1890
1891	718,162	237,558.17	.331	3,554,564	1,114,484.53	.314	1891
1892	1,567,937	507,161.04	.323	3,655,706	1,167,094.06	.319	1892
1893	703,427	207,640.02	.295	4,647,220	1,482,718.89	.319	1893
1894	377,765	132,381.22	.350	4,921,681	1,151,039.37	.301	1894
1895	1,279,929	397,978.14	.311	3,993,487	1,230,155.61	.308	1895
1896	995,626	238,878.95	.240	3,294,832	1,023,626.19	.311	1896
1897	636,740	253,277.28	.398	3,571,139	1,110,259.13	.287	1897
1898	4,772	1,110.60	.233	2,766,644	769,679.65	.278	1898
1899	957,072	219,014.46	.229	2,002,149	578,240.01	.289	1899
1900	172,434	57,398.36	.333	4,133,664	1,271,981.81	.308	1900
1901	221,131	47,139.31	.205	4,349,528	1,320,969.51	.304	1901
1902	2,768,255	947,019.08	.342	2,951,409	1,263,981.96	.320	1902
1903	[illegible]	50,098.30	.227	6,335,604	2,246,598.63	.355	1903
1904	558,952	162,026.91	.290	6,794,025	2,425,151.95	.357	1904
1905	2,556,629	1,043,015.33	.408	5,908,829	2,231,179.20	.378	1905
1906	689,552	222,992.33	.323	5,716,809	2,192,527.30	.384	1906
1907	1,883,029	753,046.33	.400	6,402,517	2,657,637.07	.415	1907
1908	28,616	11,446.40	.400	4,895,017	2,030,985.15	.415	1908
1909	1,244,661	627,136.68	.504	6,941,148	3,065,648.92	.442	1909
1910	1,049,129	416,363.41	.397	7,193,630	3,341,126.89	.464	1910

Superpower Survey—Progress Report

In our issue of Dec. 15, 1920, we gave an abstract of a preliminary report on the Superpower Survey, by Mr. Wm. S. Murray, which contained some data of interest. There has recently been submitted a progress report to the President by the Secretary of the Interior, from which the following is taken.

In the Boston-Washington industrial region under consideration the report states that there are 20 Class I railways which are divided as follows:

First track, 14,500 miles.

Second track, 6,500 miles.

Total trackage, including yards and sidings, 36,000 miles. There are a total of 10,000 steam locomotives, of which 44 per cent are freight, 29 per cent passenger, and 27 per cent switching. The total railroad coal consumption for 1919 was 19,000,000 tons.

Apparently one-third of this mileage can be economically electrified, including the greater part of double track mileage. Due to lack of traffic density upon the branch lines these can not be profitably electrified.

The above 33 per cent of mileage will carry more than 50 per cent of the traffic and by preferential arrangement of routes probably 60 per cent of the total traffic could be put over this mileage.

Through the electrification of the above mileage a fuel saving of 6,000,000 tons, or $40,000,000 per annum would be effected. Added to this saving will be $50,000,000 annually as a difference in favor of electric versus steam engine repairs and maintenance.

The total unit cost of electrification will be approximately $40,000 per mile of main line track, which with 12,600 miles to be electrified would cost $500,000,000. In addition, yard and siding trackage would call for $300,000,000 or a total of $800,000,000. This sum will cover the necessary construction and equipment for the railways beginning with the electric substations and with the driving wheel of their electric motive power.

The electrification above outlined will displace approximately 7,000 steam locomotives, which at salvage value of $22,500 each will credit the electrification estimate with approximately $150,000,000, leaving a net investment of $650,000,000, which taken in connection with the afore-mentioned savings of $90,000,000 per annum would return approximately 14 per cent on the investment.

A conference with the coal authorities indicates that a fair figure to take for the average price of coal during the period 1919, was $2.90 per ton at the mine, and that during the period from that date to 1930, $3.50 per ton.

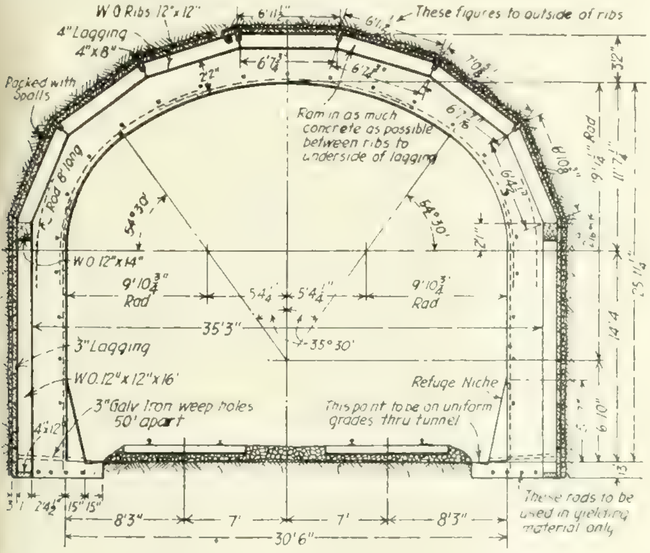
With regard to water power for the zone, a summation of the possible outputs from the Potomac, Susquehanna, Delaware, St. Lawrence (American rights), Raquette and the Adirondack powers indicate that for an average year there will be available 12,000,000,000 kilowatt-hours, and for a minimum year 8,360,000,000 kilowatt-hours; the plant capacity being 2,300,000 kilowatts to furnish this amount of energy. It is of interest at this point to state that in 1930, the total power requirement in the superpower zone indicated by projected growth curves will be 48,000,000,000 kilowatt-hours, of which amount the superpower system could supply 36,000,000,000 kilowatt-hours. This, therefore, indicates that the water power supply can be but from 20 to 25 per cent of the total.

Widening a Tunnel for Double Track

It is not often that the traffic on a newly built railway increases in density so rapidly that in a few years double-tracking becomes necessary. Such has been the case, however, on a portion of the Virginian Ry., where in a 16-mile stretch to be double-tracked there were five single-track tunnels, aggregating 3680 ft. in length. According to the Railway Review, from which the accompanying data and illustrations are taken, the work involved some rather unusual engineering features to widen out these tunnels to double track width.

As was to be expected, in the preliminary studies of this work the construction of a tunnel in a separate bore for the second track was first considered, but on account of high viaducts close up to the entrance at several of the tunnels it was found to be uneconomical to spread the tracks far enough apart for the separate bores, as such a plan would have required the erection of new bridge structures, whereas by widening the tunnels out to double-track width, there is the usual arrangement of a double-track bridge floor on the viaducts.

The original width of the single-track tunnel was 18 ft., in the clear, inside the timbering. The work of enlarging the tunnels for double track consists in removing the timbering of the single-track tunnel, excavating a heading of sufficient width for the double-track bore, placing a timber roof lining, and later removing the bench of rock and then constructing a concrete lining for the double-track tunnel.



East Portal of Tunnel Showing Protective Shield in Position and Heading for the Enlarged Tunnel "Turned."

The method of widening these tunnels without interrupting traffic includes the erection of a sectional steel shield over the track to protect passing trains against possible fall of rock or the dropping of building material from overhead. The general idea and the details of the work were devised by the chief engineer, Mr. H. Fernstrom.

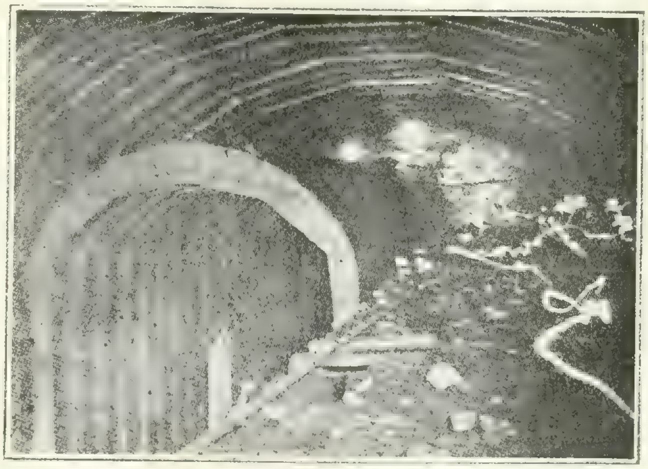
The steel shield consists of arch ribs formed by steel plates riveted to steel angle bars 5x3½ by ½ in., and 5x3½ by 7/16 in., bent to shape. These steel ribs are used in pairs 4 ft. apart with 4-ft. plank lagging between. In other words, the shield consists of lagged sections, each of 4-ft. length. To make room for the shield the side wall of the tunnel is excavated 2 ft. beyond the timbering on one side, the rock is drifted and wall plates to support the steel arches of the shield are set. The shield is erected by lifting the arch sections to place with a hand derrick on a flat car, and 15 sections are placed at one time, so that the work is done over 60-ft. lengths of protected track. The end of the wall plate drift is kept about 12 ft. back of the forward end of the shield. As each plumb post is set in advance a shield section is taken down behind and moved ahead. The side wall consists of two straight 10-in. I beams, lagged.

On the side for the second track the rock is excavated to a width of 18 ft., and the timbering of the roof of the widened tunnel is kept close up to the work of driving the heading. The heading is driven entirely through the tunnel before the work of removing the bench is begun. The rock excavated in driving the heading is run out to the end of the tunnel in cars on narrow-gage track and dumped into standard gage cars through a platform or trap.

After the heading has been driven entirely through the tunnel and the overhead timbering placed the bench is then blasted or shaken up, removed by steam shovel and loaded onto cars on the main track at intervals between the passage of the traffic trains.

West Heading in Tunnel Showing Protective Shield in Place and Poof Timbering for Enlarged Tunnel Advanced Up to the Heading Work.

For the erection of the concrete lining wooden forms are used. The concrete is machine mixed at a convenient point outside the tunnel and loaded onto a scaffold car, which is run forward to the point of operation and back, carrying about 2 yd. of material, in steel buckets, at each trip. From the scaffold car the concrete is placed in the forms by hand shoveling, in the usual manner.



Detailed Section of Tunnel for Two Tracks on Tangent. Clark's Gap Hill, Virginian Ry.

Advantages of Machine Cleaning of Cement Sacks.—The March Monthly Bulletin of the Texas General Contractors' Association summarizes as follows the advantages of machine cleaning of cement sacks: The use of a machine for cleaning cement sacks will result in securing from 125 sacks approximately 1 sack of good, first-class cement. Bundles of 60 sacks weigh on an average, when cleaned, 25 lb. as against 50 lb. to 75 lb. per bundle when not cleaned, thus reducing freight charges on the return shipments to about half that of uncleaned sacks. Again, there is no trouble in reading the owner's name on machine cleaned sacks, thus avoiding the shipping of some of the sacks, when several brands of cement are used, to the wrong place.

The Fundamentals of Helpful Public Utility Regulation

At an anniversary banquet of the Journal of Electricity held in San Francisco, Feb. 1, former President E. O. Edgerton of the California Railroad Commission, spoke so pertinently and succinctly on public utility regulation, the attitude of the public toward decisions which happen to be displeasing, the necessity of fairness without favoritism to capital, and the public ownership problem, that we quote in full Mr. Edgerton's speech, which was printed in the Journal of Electricity of Feb. 15.

The Power of Regulation and the Necessities of Capital.—I speak to you tonight about regulation—helpful regulation. Of course, it must be repressive in a measure. But the big element of regulation that is really worth while is the constructive element of it. I assert, with confidence, that regulation will be a vital factor in the development of the West in that it has such a powerful and effective influence on the development of our great public service corporations. You must realize this: that in creating state regulatory bodies the people have created an agency through which the state itself speaks. You must remember that, when your regulating body makes a pronouncement affecting the credit of these great public service corporations, the state itself has spoken. You must remember that not only those in other states but our own people look upon those pronouncements as the pronouncements of the whole people, as pronouncements by authority and of vital effect.

The most energetic, and perhaps the utility service which has expanded to the greatest degree and will have the greatest effect upon our growth in the West, is that which generates and distributes electric energy. There is one thing, and one thing only, that will get the money to finance the tremendous developments planned by this industry, and that is the confidence of the investor in the enterprise, and his confidence in the authority of the state of California towards his investment. If he lacks that confidence, there is no power on earth to force that money into these enterprises. That illustrates the importance of regulation in the development of such an enterprise having so vital an effect upon the West.

The Public and the Unpopular Decision.—The test is coming in California as to whether or not our people are intelligent enough, whether they either will be informed or will inform themselves sufficiently of the facts, to sustain sound regulation, and upon that test will depend the development of this state and the states of the West; because no matter how sound a regulating body may be, if it is not supported by public opinion it will fail. If every act of such a body is to be criticized, if because momentarily a decision which it makes favorable to a corporation is unpopular, and the agencies of publicity criticize and condemn it as an enemy of the people, and the people get the conception that, instead of working in their interests, it is working against them, sound regulation will fail. Not only will you fail to inspire confidence in the investors, but you will discourage the initiative displayed by the men who have indulged in these great visions of development. The fact is that the more development is encouraged, the sounder the policy of regulation may be, the greater the confidence the people have in the policy of the state of California towards these great enterprises, the cheaper the service is to the people. It seems an absurd proposition that the people should deliberately throw away the great asset of credit which is possible through the sustaining of sound regulation.

Now, I have great confidence in our people as a whole, and particularly our people in the West, that if they know the facts, if they come to an understanding of the situation, there will be no question about their attitude. It is a sobering thought, surely, which must come to those in charge of the agencies of publicity that they carelessly or wantonly criticize, and condemn, perhaps, some little local situation which in the broad aspect of the whole matter is trivial, and by that act break down this confidence which is so vital to the development of the West.

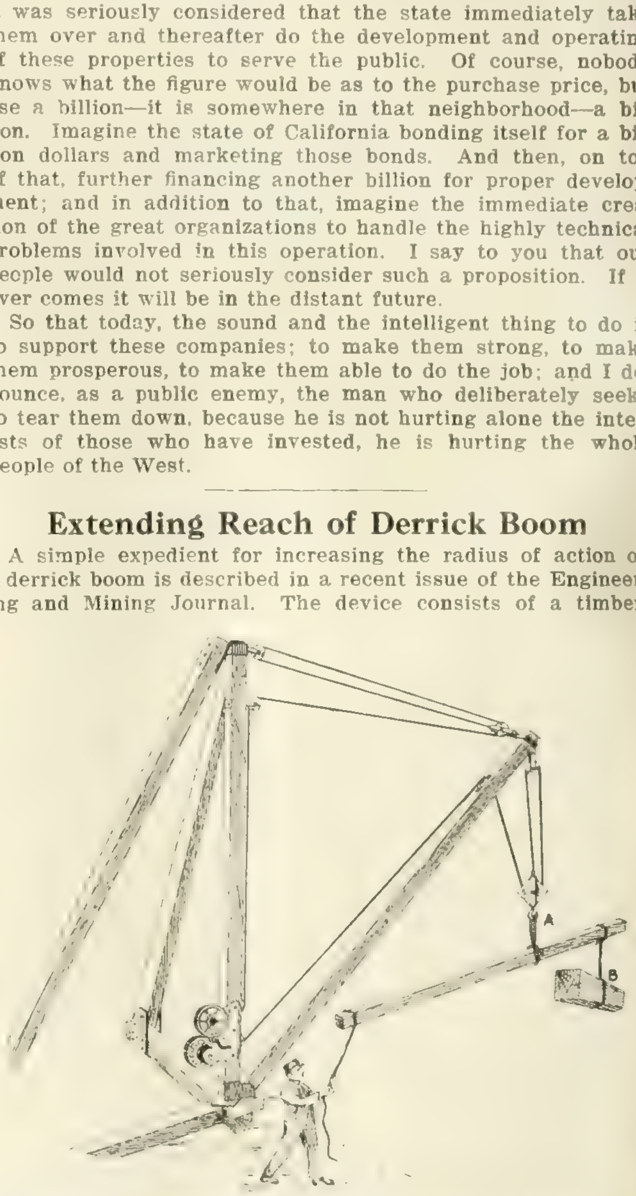
Utility Managements Recognize a Duty.—Of course, sound regulation alone cannot accomplish this task. Sound regulation must be supported by the proper attitude on the part of the utility corporations themselves. There must be the conception, from the management clear down through the organization, that the prime purpose of these enterprises has become public service, and that a selfish attitude will prove disastrous. But I can say to you now, after years of experience, that the whole tendency and the marked tendency on the part of the management of the great public service corporations is towards that viewpoint. In fact, I have heard executives of the greatest companies in the state of California announce that they are public servants, that the prime purpose of their organization is to serve the public. Of course, they are trustees for their stockholders; of course, they must conserve the interests of those who have invested their money, but their conception is that the best interests of their stockholders lie along the lines of the best service to the public.

Immediate Public Ownership Impossible.—I can say to you, after a very considerable experience, that the only agencies possible to perform the great tasks are these public service corporations. It is a practical impossibilty for the public to take over, at this time, these great corporations and operate the property in the public interests. The financial aspect of it alone makes it absolutely impossible. Conceive, if you please, the power companies alone in California, and suppose it was seriously considered that the state immediately take them over and thereafter do the development and operating of these properties to serve the public. Of course, nobody knows what the figure would be as to the purchase price, but use a billion—it is somewhere in that neighborhood—a billion. Imagine the state of California bonding itself for a billion dollars and marketing those bonds. And then, on top of that, further financing another billion for proper development; and in addition to that, imagine the immediate creation of the great organizations to handle the highly technical problems involved in this operation. I say to you that our people would not seriously consider such a proposition. If it ever comes it will be in the distant future.

So that today, the sound and the intelligent thing to do is to support these companies; to make them strong, to make them prosperous, to make them able to do the job; and I denounce, as a public enemy, the man who deliberately seeks to tear them down, because he is not hurting alone the interests of those who have invested, he is hurting the whole people of the West.

Extending Reach of Derrick Boom

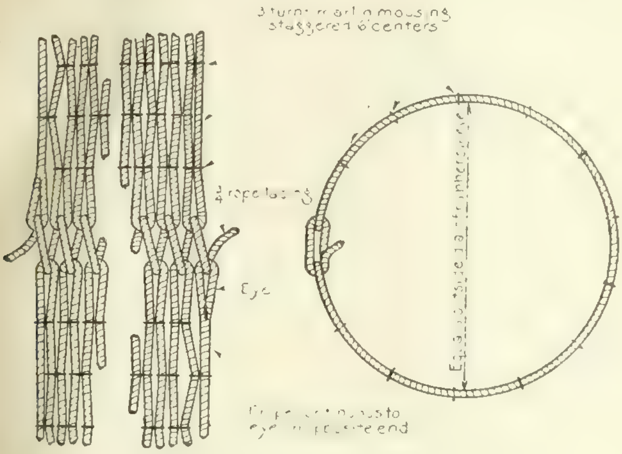
A simple expedient for increasing the radius of action of a derrick boom is described in a recent issue of the Engineering and Mining Journal. The device consists of a timber, usually a spare derrick boom, A, about which a sling is placed in such position as to almost balance the load, B. The overbalance is left on the free end of boom A, to which a rope is attached. When the load B is approximately in position, it may be easily maneuvered into place by pulling down on the rope to elevate it and from side to side to shift to position. Too great an overbalance on the free end of boom A would make the arrangement awkward to handle.



Device for Facilitating Handling of Material by Derrick.

Rope Mat Reinforcement for Rubber Dredge Sleeves

The Port of Portland, Oregon, for the past 22 years has been operating, on a large scale, hydraulic pipe line dredges, and the cost of rubber sleeves at the flexible joints in the discharge line has been a serious question, especially on the high powered 30-in. dredges. Various methods of reinforcing these sleeves have been tried with the result that a rope mat reinforcement has been adopted. This reinforcement is described by Mr. J. H. Polhemus, General Manager of the Port, in a recent issue of The Military Engineer.



Sketch Showing How Rope Mat Is Made.

The rope mat as now used very successfully on all of the Port's dredges, and the two 24-in. dredges of the U. S. Engineer Department in that district, was first designed and used by Captain Johnson on The Port of Portland's 30-in. dredge Tualatin in 1917.

This mat is made of old rope stretched over a rack and tied with rope yarn. The mat is then placed on the rubber sleeve and laced in place. The accompanying drawing clearly shows how the rope mat is made. Old rope makes a better mat than new rope, due to the fact that the stretch has been taken out.

The material handled by these dredges varies from coarse, heavy sharp sand to heavy gravel. Some clay is encountered at various locations in the harbor and is awkward to handle. It has been found necessary at times to shut the dredge down as many as 50 times during a 24-hour day to clean the pump but, of course, this is unusual.

The average harbor dredging conditions require a 3,500-ft. pipe line and 30-ft. lift from water surface to top of fill, the pipe line pressures running as high as 50 lb. per square inch.

Spare 30-In. Rubber Sleeve Fitted With Rope Mat.

Mr. Polhemus states that the average life of the 10-ply, 30-inch. rubber sleeve, such as has been used by the Port, served with rope mats, under average dredging conditions, is 300 working days. The average life of the same sleeve under like service without the mats is 150 working days. Hence the life of the rubber ponton pipe-line sleeves has been doubled by the use of this simple and inexpensive rope mat. Also the wear and tear is much more severe on the large 30-in. dredges than on the 20-in. dredges, and the sleeves are subject to more accidents, making the rope mat protection the more necessary.

Successful Labor-Saving Devices on an Electric Railway

Mr. Charles H. Clark, engineer maintenance of way, Cleveland railway, writing in the Electric Railway Journal, gives his experience with a considerable number of labor saving devices. As a proof of their efficiency, he states that since 1914 wages per hour have increased 163 per cent, while total labor on track has increased only 64 per cent. The following is quoted from his article:

A derrick with a 50-ft. boom can be used to pile material high, saving trackage and yard space. Granite blocks on our property are sometimes piled 25 ft. high, which could never be done by hand.

Another useful device on an electric railway property is a stone crusher, which will save tons of old stone otherwise useless. Old paving stone can be crushed for from 40 to 50 ct. per yard. In normal times crushed stone would cost $1.25 to $1.50 per yard. A crusher also saves the expense of hauling crushed stone to a dump and unloading it.

There are further opportunities for saving in connection with cement. Cement bags as dumped at the mixer usually contain some cement, which we save by means of a bag cleaner which we constructed. A test showed that 1,000 bags weighed before cleaning 1,313 lb. After cleaning they weighed 606 lb., so that we saved 707 lb. of cement and the freight on this weight of bags shipped back to the mill. The saving in freight more than paid for the cleaning. We also lessened the expense of piling cement in the storehouse by the use of a belt conveyor and electric trucks.

Sand driers are a source of expense to a large road. We have used a large rotary drier for about seven years, and with it two men can dry from 100 to 150 tons of sand per day. On the Cleveland railway we also use a portable sawmill on a flat car for sawing up old ties into blocks used for blocking up tracks and also for emergency heating purposes.

In Cleveland most of the trackwork consists in relaying tracks, involving the taking up of the pavement. This we do with a pavement plow which will loosen 7,000 sq. ft. in three minutes. Concrete track foundation also has to be broken up. Instead of using picks, hammers and bars as formerly, we now break it up with a special machine that will do the work of 100 men. After breaking out the foundation, we cut up the old rails with an oxyacetylene torch, with which two men can cut more rails than can twenty working with chisels.

In excavating, the electric shovel can be used where space is available. In Cleveland, after the excavation is complete, the rails are laid on the ties, the old material is hauled away in work trains and new material, such as gravel, crushed stone, sand, cement, etc., is brought in. The joints are then riveted with a pneumatic riveter, which heats rivets under 100-ton pressure and can drive eight of them in less than four minutes.

When the track is ready for concreting, the concrete mixer comes into play. We first used these mounted on wheels alongside the track, but now we have them mounted on car wheels with a distributing boom 30 ft. long. We formerly required 24 men to run and feed the mixer, but now use only eleven. We have also increased the number of batches mixed per day by 20 per cent by the use of a loading device attached to a 30-ft. conveyor.

A small item in labor-saving devices, but an important one is the common dirt shovel. We buy the best chrome-nickel shovel we can find. While these cost twice as much as the common ones, they last four times as long and do not wear down to a small spoon-like tool. We use an identification mark of three holes drilled in the blade.

U. S. Steel Corporation Cuts Prices.—The first price revision by the U. S. Steel Corporation since March, 1919, when prices were fixed by the Industrial Board, was announced last week. Under the revised list structural shapes were reduced $5 per ton; plates, $9; bars and wire rods, $9; plain wire, $7; sheets and small billets, $4; slabs, $4.

Subsidence and Shrinkage of Embankments

The following is taken from appendix E of the report of the Committee on Roadway of the American Railway Engineering Association, presented at the March convention:

Subsidence.—Subsidence occurs principally and to the greatest extent in marches, swamps, bogs and wet lands, the reason obviously being that the natural ground will not sustain the combined embankment, track and loads.

In many cases the yardage below the original natural surface of the ground was found to be several times the quantity of that above it. In preliminary work there is no fixed rule for determining what amount of subsidence will occur. The engineer locating a new or additional line through bogs, swamps, marshes, etc., would do well to make allowance for considerable subsidence. In some cases, before building, soundings have been taken with a view to locating the hard surface under swamps, bogs, etc., and allowance made for the fill to subside to that level. This is not always possible, however, and it sometimes happens that this hard surface will break under the weight and subsidence continue indefinitely.

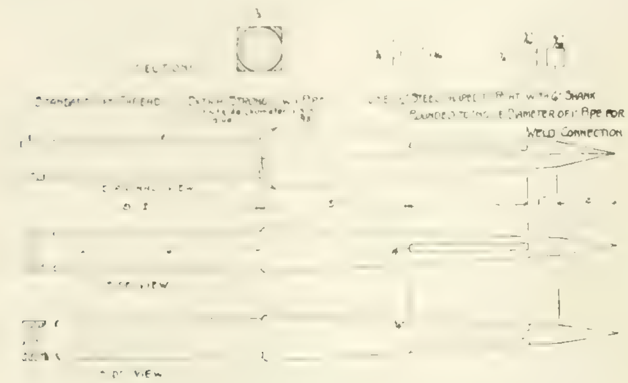


Fig. 1—Grooved Point Sounding Rod.

It was found that subsidence to some extent will invariably occur under embankments built through ordinary grazing or agricultural land. This applies to the greater percentage of embankments as most of the land in the country comes under this class. This is due to the loose formation of the upper crust of the ground, which has not the bond, weight or density of the lower beds due to the roots of grass and other vegetation, plowing and the action of frost keeping the bond continually broken up. The percentage of subsidence will be much greater on the small fills by reason of the smaller area of the base and the tamping action of trains. On the larger and higher fills the base is spread over a much greater area and the tamping action is not so pronounced at the base, consequently the subsidence is proportionately less.

Methods of Determining Extent of Subsidence.—There are three methods of determining the extent of subsidence: (1) Trenching; (2) bar or auger borings; (3) wash borings.

The Committee would like to call attention to the good results secured in determining the extent of subsidence on small fills by means of a slotted and pointed bar, which, when driven to the bottom of a fill and turned leaves in the slot a specimen of the material at that point. For convenience of handling an extension may be put on the bar. This method, however, would not be practical on fills of over ten (10) feet. Great care should be taken in recording the measurements of the different depths. A plan of the grooved point sounding rod is shown in Fig. 1.

Trenching is the most accurate method of determining subsidence. It is not, however, always practicable or possible to trench, in which case the boring methods must be used. Wash borings are more or less inaccurate and should be used with care. Several roads report they are unable to get any real results from their use, the holes filling with soupy, muddy water and the dividing lines of the strata impossible to determine. Dry borings protected by casing, if necessary, have given good results when proper care has been taken in making and recording same. In determining the extent of subsidence, care should also be taken in locating the line of the natural surface at the toe of the embankment. On account of the earth often sliding or washing down and spreading out at the toe, a very gentle slope is left, which can easily be mistaken for the matural surface.

Causes of Subsidence.—Subsidence occurs in two distinct ways. By compression and by displacement. On ordinary land the upper strata of earth being weakly bonded will tamp and compress, permitting the fill to subside. This will also occur in shallow swamps, such as muskeg, or where water standing on the ground will lessen its bearing power. Subsidence from this cause, as a rule, is not serious from an operating standpoint as it will cease after the strata of soft material immediately under the fill is sufficiently compressed or tamped. Great and serious subsidence is caused by displacement. In deep, bottomless bogs and swamps, the embankment often continues to subside, displacing large quantities at the sides and requiring constant attention to prevent the interruption of traffic. In some such cases embankments have been known to reach a state of equilibrium without having reached a solid bottom, but this has taken a considerable time. Others are still subsiding after many remedies have been tried and it seems probable will continue to do so indefinitely.

The effect of subsidence is to lower the base of the fill, causing a corresponding shrinkage of the track structure, involving heavy maintenance charges, and in some cases so large as to justify the abandonment and relocation of the line.

Conclusions of Committee Regarding Subsidence.—Some subsidence occurs under all embankments built on any ground except rock. It is very light in sand and gravel. The percentage of subsidence is greater under small fills than ununder a larger one.

Subsidence is due to compression or displacement of the strata of earth under the embankment.

Subsidence must always be anticipated in swamps, marshes and bogs, and any land on which there is standing water.

Serious subsidence is local and it is impossible to fix any rule as a guide in estimating on anticipating same.

Shrinkage.—The question has been raised as to whether shrinkage actually exists. It is felt by the Committee that the existence of shrinkage is proven by every ditch or sewer line and every post hole. Every observant person knows that material excavated for a sewer when placed back in the trench after the laying of the pipe even if it be ridged up on top, will, in a short time, pack and settle so as to leave a depression, showing the earth excavated to occupy less space than before the bond was broken. In fencing it will be noticed that the dirt excavated will not fill the hole up even after the post has been placed in it.

Density Methods of Making Shrinkage Test.—The Chicago, Burlington & Quincy, Duluth, Missabe & Northern and Duluth & Iron Range railroads have made shrinkage tests by the density method, which may be briefly described as follows: Samples are taken from various points in embankments with an iron or steel cylinder of known cubical capacity, care being taken to neither compress nor expand the material. The same thing was done in adjacent excavation when it was quite certain that the embankment was built from this excavation. These samples were taken to the laboratory, where they were weighed and placed in a dry, warm or hot place. When samples were quite dry they were again weighed. The differences in weight is taken as measurement of change in volume.

The results obtained indicate that the experiments should be carried on more extensively. Some remarkable ideas are developed, such as that the shrinkage of material is proportional to its weight, and weight depends on the depth in the natural bed. These subjects are capable of great and interesting development. From the results as obtained by this method it would seem the net shrinkage (making no allowance for subsidence) of common earth, would average close to 9.5 per cent, and as 10 per cent is the commonly used allowance this would show it to be approximately correct. It is recommended that further experiments be made and the profession be given the benefit of the results. The experiments prove that shrinkage does exist.

Shrinkage is composed of four elements:

Causes of Shrinkage.—(a) Wastage due to loss in hauling material from cut or pit to embankment. This is usually very small and may be neglected.

(b) Wastage due to wind erosion. This is an element which varies with the climate and nature of material. The exact percentages are practically impossible of determination.

(c) Wastage due to water erosion. This is a large factor and very difficult of exact determination, except where large washouts have occurred. It varies with climate, but often is quite as large in dry climates, which have sudden freshets as in wet climates where there is an almost continuous water erosion.

(d) Compression, which is by far the most important cause of shrinkage. The condition of the material in its natural bed is usually the result of sedimentation in water and generally the particles are not compactly assembled, but are slightly cemented and thus have a temper that may be very hard to break up. Heavy plowing, picks or even blasting may be required to make it workable. After this cementaceous bond is broken up the particles will settle together much more compactly, particularly if mechanical means are used to compact them, such as the trampling and rolling caused by teams, wagons, slip or wheel scrapers and later by the pounding of locomotives and cars. Water tamping will produce a similar compacting to a large extent. This water tamping is sometimes artificially applied, but usually rains furnish the water, and the railway traffic, during both wet and dry weather, brings about a combination of water and mechanical tamping. The result is a very great shrinkage.

There is considerable confusion in the use of the terms shrink and settle. For instance, the following is a common statement: "Fills built by teams and scrapers will shrink very little, while fills built by dumping from trestle settle enormously." Investigation shows that this is in error, as the fills constructed by dumping from trestle will sometimes take years to be water and train tamped to their ultimate compactness. Two fills, one built by each of these methods from identical material, will finally show very little difference. The only way shrinkage can be definitely determined is by comparison with the excavation quantities.

Settlement, as used herein, may include three elements, which are shrinkage, subsidence, and a reduction in height and volume that is neither. Settlement is the decrease in height or volume or both, of an embankment or the bed of a cut from the moment of construction, until it becomes stable. Settlement may cover a change from a volume, which is larger than that found in excavation, to a volume that eventually is less. It may be a reduction from a swelled volume to the original volume as found in excavation. From this point, settle would also be shrinkage, if the volume decreases. Subsidence is an element of settlement and may be defined as the result of a downward movement of embankment or ballast material below the natural surface line. Subsidence causes a compression downward or a displacement horizontally of the underlying material. It may be either under embankments or in cuts. Settlement may occur without there being either shrinkage or subsidence, but there can be no shrinkage or subsidence as herein defined, without settlement.

From the information received by the Committee, it is found that an allowance of 10 per cent for shrinkage of earth is almost universal and is generally very nearly correct. In practically all cases this is assumed to also cover the slight subsidence which will occur in arable land or glacial drift. Every problem has certain local aspects and it would always be well to determine what has happened locally in the way of shrinkage and subsidence if very accurate results are desired. In common practice, however, when grading with earth, a 10 per cent shrinkage allowance is recommended. When the harder substances, such as rock or shale, are encountered a negative shrinkage or swell is found. Reliable data received by the Committee shows that in many cases of work of this nature the swell has been from 2 or 3 per cent to 60 and 70 per cent.

The method of handling as well as the material will have a bearing on the swell of this material. Rock and shale will be found to vary considerably in different parts of the country. No rule is found that can be generally applied. The method of handling and shooting must be considered in anticipating swell. Local formations and conditions will govern to a great extent in this class of work.

It is estimated that approximately 90 per cent of the grading quantities in this country would be classed as earth or common excavation. Rock and shale work, therefore, would constitute only approximately 10 per cent of the quantities.

As stated previously by this Committee, it is not recommended that the height of fills be raised to allow for shrinkage, but that the additional width be put on the shoulder. This is due to anticipated settlement not always occurring, especially in fills built by teams and scrapers. Quite a number of roads, however, are following the practice of building fills by dumping from trestle on fills 10 ft. and more high, constructing the trestle one foot above the grade to allow for settlement. This, of course, cannot be done if the location of bridges interferes, but seems to work out well generally.

Suggested Studies in Rail Manufacture

In a paper on "Steel Rails" presented before the Western Society of Engineers, Mr. C. W. Gennet, of R. W. Hunt & Co., has suggested the following list of questions as being pertinent to modern practice:

1. Are rails made of steel by the Continuous Talbot furnace process comparable with those made by the straight open hearth method? In the continuous process the furnace is seldom emptied but a hundred tons or so of steel is tapped every two hours, as against the 10 hours of time required to make an equivalent heat in a regular furnace. Is the steel from the rapid working Talbot furnace sufficiently free from oxides and other impurities to afford good, sound rails, and how can such a matter be quickly proven?

2. What effect, if any, on rails has steel made by the Duplex process, wherein highly oxidized metal is added to the open hearth furnace, sometimes very soon before tapping? How can rails rolled from steel containing excessive amounts of impurities be detected?

3. What effect on rails is produced by recarbonizing the steel in the ladle with coal or coke and then adding cold deoxidizers to the ladle? What is the real effect produced by holding a ladle of steel prior to casting the ingots to permit of time for the chemical reactions to settle?

4. What is the effect on rails rolled from ingots cast with running stoppers and sometimes without any control by the ladle operator? How does the size of the nozzle, pouring temperatures, and time required to cast the ingots of a heat influence rails?

5. How soon after casting ingots should they be charged into the soaking pits in order to assure a minimum of piping and segregation? What effects are produced by delays in promptly charging the ingots to the pits, and what is the effect of unduly and rapidly chilling the outside or skin of the ingots?

6. How long a time and under what conditions of gas and air regulation should ingots remain in the soaking pits? What kind of control of the pits is best to insure against overheating or burning the ingots? What is the effect of rolling rails from ingots one side of which has been heated so hot as to show a bright white spot significant of overheating?

7. What effect on rails has different rates of blooming the ingots? In some cases 8 by 8-in. blooms are made from ingots in nine passes and in other cases in 20 passes. Some mills work rapidly and others slowly; does this produce any difference?

8. What effect on the grain structure or the life of rails is produced by increasing the number of passes, or work given to the steel, when the ingots are rolled into rail? One mill makes a rail from a 19-in. square ingot in 15 passes, while another mill makes the same rail from a 24-in. square ingot in 29 passes. Has the average rate of reduction per pass any effect on the life of rails?

9. What matters mostly influence the production of rails showing seams on the surface? Some heats are practically free from indications of seams, while on other heats rolled at the same time seams are abundant.

1921 Convention, National Highway Traffic Association.—The National Highway Traffic Association will hold its 1921 convention at the Detroit Athletic Club, Madison and John R. Sts., Detroit, on Friday, April 29. Sessions will begin at 10:30 a. m., 2 p. m., and 8 p. m. The convention will be devoted to the presentation and discussion of progress or final reports of standing committees. The following list includes some of the important subjects pertaining to traffic regulations and efficient and economic highway transport which have been assigned to committees. Complete programs may be obtained from the president, Arthur H. Blanchard, Engineering Bldg., University of Michigan, Ann Arbor, Mich., or from the secretary, Elmer Thompson, Automobile Club of America, 247 W. 54th St., New York City.

Some Data on Shallow Dredging

In the construction of the New York State Barge Canal a number of high grade dredges were used. Some interesting data on the operations of some of these dredges were given by Mr. Friend P. Williams, division engineer, New York State Canals, in a discussion of a paper* presented to the American Society of Civil Engineers.

The log of one of these dredges, a 20 in. hydraulic, operating at a depth of 12 ft., is shown in Fig. 1. This shows that from considerable intervals the dredge was operated for approximately 20 hours per day, with the exception of shut downs for washing the boilers, which occupied about 2 days at 3-week intervals.

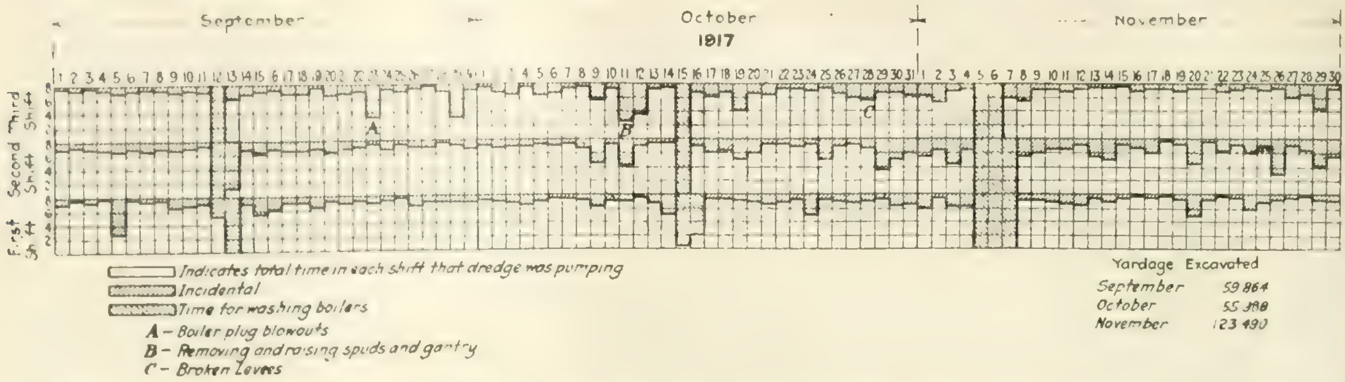


Fig. 1.—Diagram Showing Number of Hours in Each Shift That Hydraulic Dredge Lyons Was Operating During September, October and November, 1917.

The policy in connection with operating this plant is to carry a very large number of supply parts, and also to maintain a good machine shop. It is a routine matter for each shift on going to work to inspect the plant, tighten up loose bearings and make any repairs that will keep the machinery in running order. This is found to be very effective in cutting down repairs.

During the months of September, October and November, shown on Fig. 1, this dredge, the Lyons, was working in hard material in the Clyde river. Much of the material had to be drilled and blasted and consisted of clay, gravel, and soft shale. The following shows the performance of this dredge for several .months:

1917	Cu. yd.	1918	Cu. yd.
May	12,360	January	50,670
June	31,460	February	49,770
July	73,880	March	28,490
August	60,800	April	90,380
September	59,864	May	29 440
October	55,988		
November	123,490		
December	34,230		

The greatest record, however, was made by a second dredge on the same work—the 20-in. hydraulic dredge Clyde, which is not as powerful as the dredge Lyons. The Clyde in August, 1911, removed 480,681 cu. yd. of "pay" material in the north end of Cayuga Lake. The gross yardage, including material outside of "pay lines," was 633,561 cu. yd. The material in this case was sand and silt, the most favorable for hydraulic work.

In operating these dredges for 24 hours, it is evident that, excluding the time for washing the boilers, operation continued the greater part of the time. It is also shown that in operating a dredge continuously with three shifts, repairs should be made and the boilers washed at the time when most needed, rather than continuing to run inefficiently in order that repairs can be made during a particular shift, as would doubtless be the case where a dredge has operated two shifts, with a tendency to throw the repairs in the third shift.

Blasting a Drainage Ditch Through Sand

By O. O'B. STRAYER.

The Consolidated Land Co. having acquired a large tract of typical flatwoods land on Kissimmee Island, Florida, encountered difficulty in draining it, because of a troublesome stratum of quicksand underlying the sandy topsoil. It was desired to blast the ditches with dynamite. Dynamite, however, is seldom used to blast ditches through sand. Few blasters succeed in getting results working in sand, especially when quicksand is present to complicate matters. Putting down the bore holes presents a problem. It is easy enough to make the holes, but difficult to keep them open long enough to get the charges of dynamite loaded. We tried pointed bars, loading pipes and finally soil augers. Strangely we got the most satisfactory results with the latter, but had to work fast to prevent our holes from filling before we could load them.

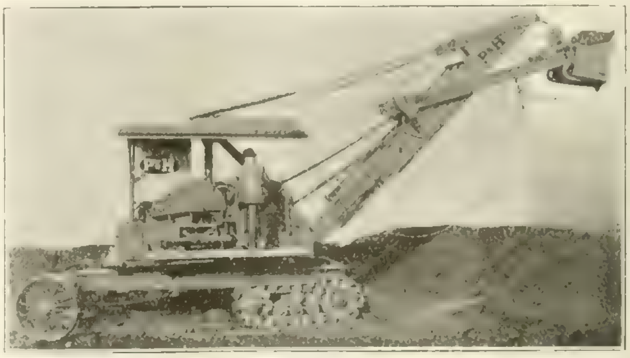
After lining out our course, we ran two parallel rows of holes, the rows spaced 30 in. apart and the holes 20 in. apart in the rows and 3½ ft. deep. Each hole was charged with 1½ lb. of 50 per cent straight nitroglycerine dynamite.

As the sand was saturated, the propagated method of blasting was employed; that is, a detonator was attached to the charge in the middle hole only of each section loaded. The other charges down the lines both ways from the center were discharged by concussion from the primed hole.

Taking one section as an example: A shot made 120 ft of ditch, 16 ft. wide at the top, 4 ft. wide at the bottom and 5 ft. deep. Two hundred pounds of dynamite and two electric blasting caps were used. Three men did the work in four hours. Using 1½ lb. of dynamite to the hole, two rows of holes, the cost including labor was 23 ct. per cubic yard, figuring dynamite prices on the carload basis.

Shovel Attachment for Gasoline Crane

A complete shovel attachment can now be obtained for the general utility gasoline crane and excavator made by the Pawling & Harnischfeger Co., Milwaukee, Wis. This shovel attachment may be applied to any 205 or 206 K. C. excavators of the above firm. The new parts are: One dipper and dipper handle; 1 boom; 1 boom foot socket casting; 1 thrusting shaft complete; 1 operating lever bearing, 1 brake treadle with ratchet, and necessary levers for same; 1 thrusting chain, 1 set of boom swing braces.



P. & H. Excavator Crane Equipped with Shovel Attachment.

These parts can be applied to the machines, without additional drilling of any kind. The dipper is of ½ cu. yd. capacity. The shovel attachment is operated by the standard levers on the machine, with the exception of an additional brake attachment to one of the brake treadles. This attachment can be quickly removed in case it is desired to reconvert the machine back into a drag line or for operation with a clamshell bucket.

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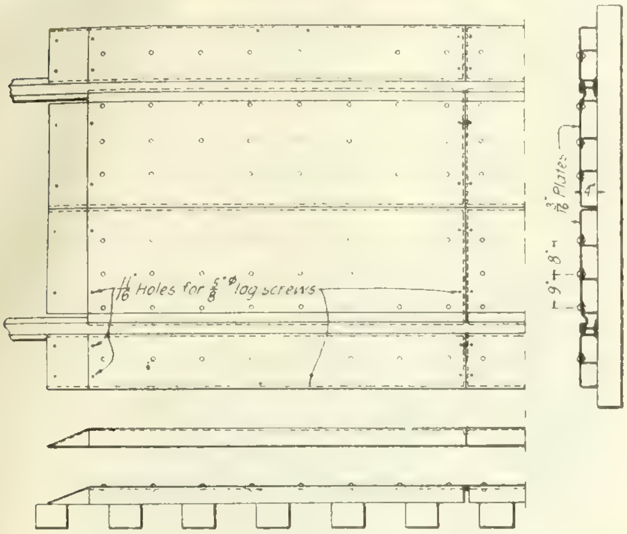
*[illegible]

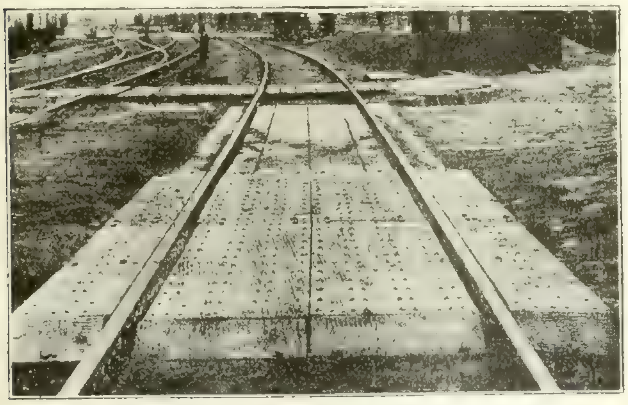
Steel Plate Highway Crossing

Visitors at the Exhibition of the National Railway Appliance Association at the Coliseum in Chicago last month were shown a full size model of a structural steel highway crossing, manufactured by the National Highway Crossing Co., of Burlington, Iowa. The photograph reproduced herewith shows an installation of this crossing on the Chicago, Burlington and Quincy Ry.



Plan of Steel Plate Highway Crossing.

The advantages claimed for this type of construction by the manufacturers are as follows: Low maintenance because of resistance to wearing; neat construction with a well-formed flangeway adjacent to the rail; better protection for the ties which are covered against accumulations of mud, gravel, snow and sleet, yet afforded thorough ventilation and freedom from any influence from freezing and thawing.



Steel Plate Crossing on C., B. & Q. Ry.

How to Steer a Traction Wheel Shovel

In moving a traction wheel shovel equipped only with hand steering device from one job to another over pavement the hand steering device is often inconvenient and slow. In the April Excavating Engineer, Mr. A. M. Owen, a well-known shovel operator of Dixon, Ill., gives the following method of steering a shovel of this type. This method of steering is, of course, not recommended for use on shovels equipped with power steer, as it produces side strains on the dipper and boom.

Drop the dipper as close to the front truck as possible, midway between the wheels. Attach a ¾-in. chain to the axle just inside the wheels, by putting a ¾-in. bolt through the links with a washer on either side. Run this chain through the dipper braces making it fast to one of these by looping the chain around it. Then attach the chain to the other side of the axle just inside the wheel.

Loosen the chain from the hand steering device so that the wheels can be turned freely in either direction. Then raise up with the boom engine till the chain is tight and put a 1¼-in. nut in the racking on the dipper stick to hold the dipper stick in this position. Then pull up with the hoisting engine till the hoisting cable is tight. This must be done carefully.

Now use the swing engine for steering. The front axle turns as the dipper moves to one side or the other.

This steering device can be put on or taken off in three minutes, and of course is much better than putting the dipper out to one side and skidding the machine to the position wanted, as is often done.

Specially Designed Skids for Dragline

Specially designed skids were employed for mounting the dragline excavator used in the Multnomah County Drainage District No. 1 of Oregon. The machine, a class 14 Bucyrus, was used in building 6,000 ft. of dike, occupying 10 ft. in height and involving a yardage of 101,000 cu. yd. The skids were 24 in. x 30 in., 55 ft. long. These traveled on eight cross logs 30 ft. long and 18 in. thick, hewed flat on two sides. These logs were kept well greased. After moving ahead the cross logs were picked up with a cable loop attached to the dragline bucket and swung in front of the machine.

The machine was moved by means of a double-drum American donkey engine with cylinders about 8x10, mounted on the front of the skids. To the drum was attached a set of double blocks and ⅝-in. line, 1,000 ft. of 1⅛-in. line was run ahead and anchored to a deadman. This line was in 200-ft. sections. After the machine moved ahead 200 ft., the set of double blocks was run out to the next 200-ft. section. In moving ahead the ground man operated the moving engine and the dragline operator helped start the load by setting the bucket as deep as possible and giving a quick pull on the loading line. The dragline bucket was also used to hold the machine in line in rounding curves where there would be a tendency to slide to one side.

Steam was taken from the dragline boiler to the moving engine through pipe and swivel joint connection through the center of the dragline. One man on the ground took care of the entire moving operation which was controlled by the operator.

New Rubber Block Treads for an Industrial Tractor

The Cleveland Tractor Co., Cleveland, O., makers of the Cletrac "tank-type" tractor, has recently brought out a new design of rubber tread tracks to be used for industrial work where the tractor must be operated over wooden floors or other surfaces that would be subject to damage by metal cleats or grouters. The method of manufacturing the rubber blocks for the treads is the same that has been used successfully for years in the manufacture of solid rubber truck tires and is accomplished by vulcanizing the rubber to a standard 7-in. single truck tire channel. Each rubber block is attached to a track shoe of special design by means of two bolts which are keyed and vulcanized in place and pass through the tire channel base, extending far enough to pass through the base of the track shoe. The method of applying these rubber blocks to the track shoe permits of quick and easy renewal when necessary. Each rubber block presents a surface of approximately 3 in. x 6 in. in connectact with the floor, and since the weight is distributed over a number of blocks on each track, the ground pressure per square inch is only about 14 lb. The rubber block extends 1¼ in. above the top of the tire channel base. Each track to which these rubber blocks are attached is made up of 37 shoes, or a total of 74 shoes on each tractor.

Parts of New Rubber Block Treads for Industrial Tractor.

Spader in Pneumatic Hammer Cuts Costs and Expedites Work on Chicago Sewer Tunnel

A revolution in tunneling methods in stiff clay has apparently been effected by the introduction of special spades fitted to pneumatic hammers by safety retainers. While we have no record of the use of these tools on other than tunnel work, they should prove similarly satisfactory in a variety of circumstances.

The Calumet Tunnel.—The case here reported is that of the 3-barreled tunnel now under construction from the pumping station of the Sanitary District of Chicago, near 125th St. and Indiana Ave. to the site of the Calumet sewerage treatment works—a distance of about 2,300 ft. in very stiff clay. The spades used on this work are known as "Bronson Digging Spades," and the first lot were manufactured for Mr. Dan O'Connor, Superintendent for The American Sewer and Drain Construction Co. of Chicago, contractors on this work.

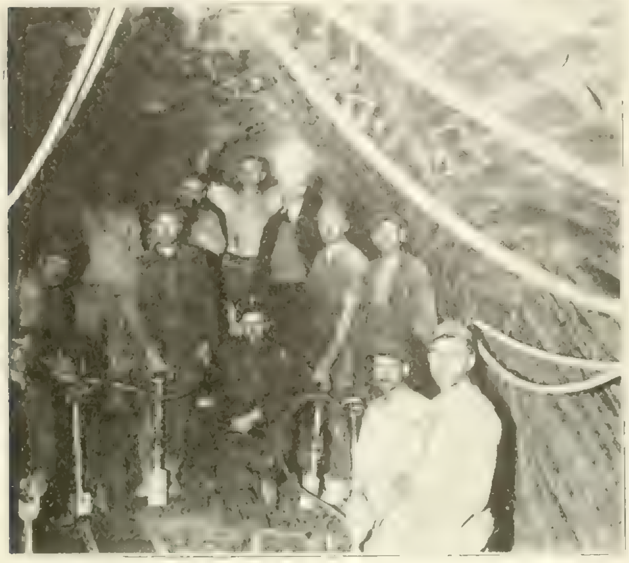


Fig. 1—Crew and Air Tools in Tunnel Heading.

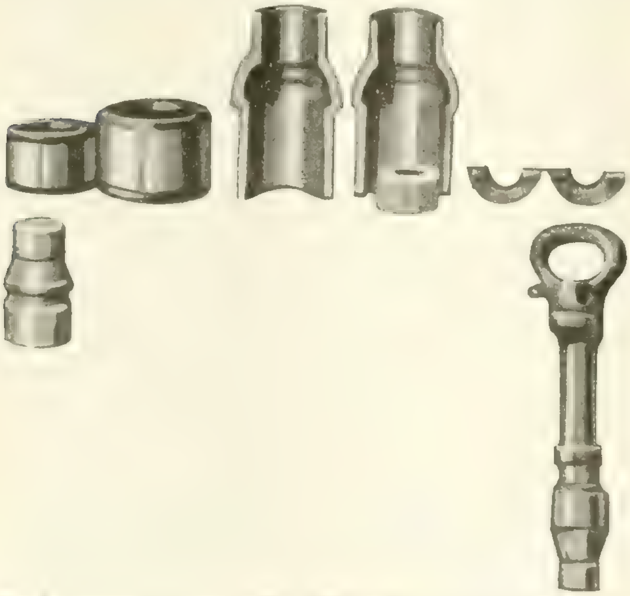


Fig. 4.—Special Bronson Safety Retainer on No. 90 Thor Riveting Hammer for Use With Bull Points Clay Chisels and Other Tools.

Bronson spades and safety retainers later were used on the tunnel under the Sanitary District Drainage Canal at 39th St. and Crawford Ave., with success. Here also they used the retainers on riveting hammers with bull points and clay chisels where boulders and rock were present with most favor

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The Work and Its Progress.—A foreman, five miners, two muckers, and one car pusher would have been considered a working unit for the Calumet job under ordinary tunneling methods, but after the introduction of the pneumatic spades it was found that the proper organization was one foreman, four miners, six muckers, and two car pushers. Under old methods on work of this character one miner was expected to turn out 3 or 4 cu. yd. per 8-hour shift, but with the new equipment and organization this rate per miner was increased to between 8 and 10 cu. yd per 8-hour shift, and the limit of work was set by the disposal of the muck instead of by the rate of digging.

Almost a Year Ahead of Contract.—On Feb. 7, 1921, about 40 per cent of the work had been completed, and it is now expected that June 1 of this year will see the completion of the entire contract. The contract requirement for completion is May 1, 1922.

The finished tunnel will consist of three concrete barrels, respectively, of 5½ ft., 7½ ft., and 9 ft. greatest inside dimensions. The 7-½ft. section is built first, and after the concrete has set the other sections are driven—one on each side of it.

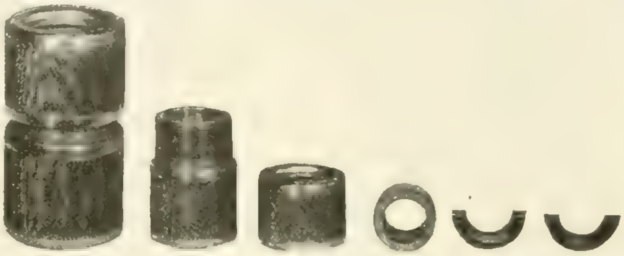


Fig. 3.—Bronson Safety Retainer Assembled and Unassembled.

Mr. George C. D. Lenth, Consulting Engineer, Chicago, has reported that during the first 58 days of tunnel work after the introduction of Bronson spades the 9-ft. barrel was driven 764 ft., the 7½-ft. barrel 883 ft., and the 5½-ft. barrel 822. These drives he reduces to an average of 14.2 ft. per day for the entire 3-barrel section. Since the respective ratings of 9 ft., 7½-ft. and 5½-ft. are for the finished openings inside the concrete linings, the excavated sections for each barrel are larger by from 2 to 4 ft. About the middle of March the rate of progress was greatly increased, and two 8-hour shifts drove as much as 20 or 25 ft. in one day. It is now thought that progress can be maintained at this rate, or about 1 ft. of completed tunnel for every working hour.

Mr. Lenth states that the cost of excavation, including disposal of material on the dump, is a little less than $5 per cubic yard, with miners being paid $1.25 per hour, muckers $1.12½ per hour, and other labor $1 per hour.

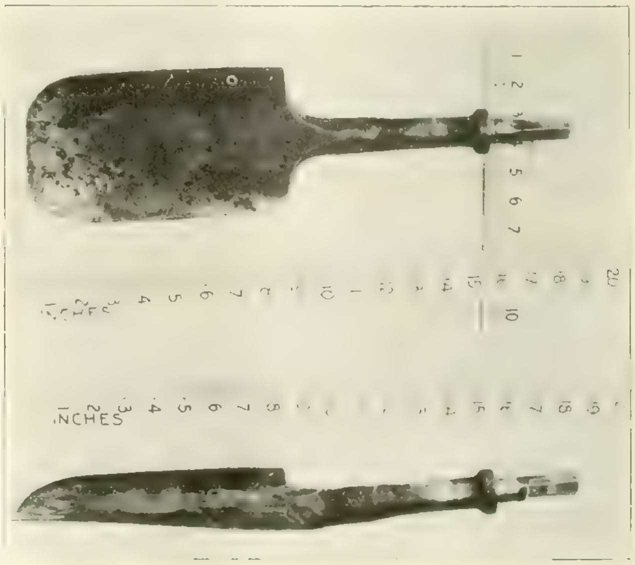


Fig. 2—General Design of Bronson Spade.

Some Details of Equipment.—The Bronson safety retainers are made to fit all types of air hammers and electric drills, and can be fitted to hammers now in use and not made to receive retainers. They can be used with many tools such as spades, chisels, bull points, star drills, rivet sets, etc. The spades can be used in almost any type of hammers. However, there are several types which are best suited to this work, and the best results are probably to be obtained with these hammers.

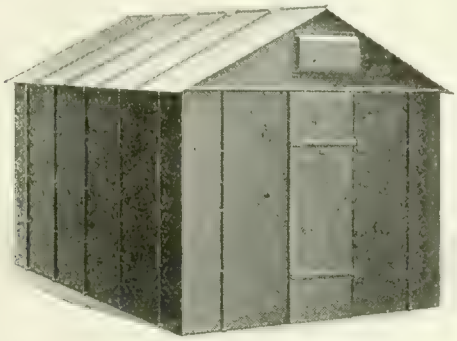
Spades are designed to meet the particular conditions on which they are to be used.

The two most important features of the retainers are clearly shown in the illustrations, and consist of the rubber bushing and split ring. The split ring permits removing the tool from the retainer no matter how broad the working end of the tool is, and saves the necessity of a split shank. It is important to know that most spades which break can be repaired.

The special spades and retainers are being marketed by Mr. Frank E. Maier, 122 S. Michigan Ave., Chicago.

Steel Storage Magazines for Explosives

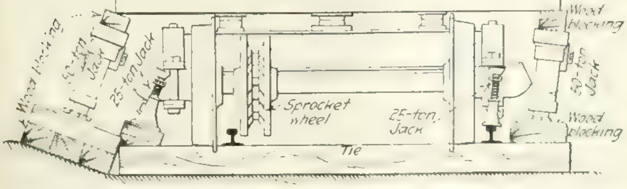
A steel storage magazine, consisting of a steel house furnished knock-down in convenient sizes for handling, is being manufactured by Littleford Bros., Cincinnati, O. The magazine is made in sections having the edges grooved so that when placed together they will interlock snugly forming a seam. Sections are held firmly in place by "U" bolts to the interior steel angle frame work making the joints waterproof. The frame work consists of steel angles and the covering is sheet steel 3/32 in. thick. The joists are heavy angle bars, inlaid with oak pieces to which the floor is nailed. Ventilator in each gable is screened with wire on inside. Door is hung on two heavy wrought steel hinges, and is secured by means of two heavy steel hasps and staples. All material is painted on both sides with two coats of graphite paint. These magazines are made in ten different sizes. It is an easy matter to erect these magazines as the instructions for building foundations and assembling, which are furnished by the manufacturer, are very complete and simple. This type of steel house also is being extensively used by contractors for tool houses. The knock-down feature makes them very economical owing to the fact that they can be very easily moved from one job to another.



Steel Storage Powder Magazine.

Jacks Used To Replace Derailed Steam Shovel

In moving a 100 ton steam shovel backwards around a sharp curve, the last pair of wheels dropped off on the inside of the curve. Ordinary methods of replacing the wheels failed, the difficulty being that the sprocket wheel for the chain drive was on this axle and would engage the frog on the inside rail, shoving it out of place before the wheel could engage it.



How the Jacks Were Used in Replacing Derailed Steam Shovel.

The method that finished the job in less than half an hour on first trial is shown in the sketch, which is reproduced from the Engineering and Mining Journal. The jack arms were not used. Blocking the other truck to prevent the shovel moving either forward or back, the dipper was rested on the ground just on the outside of the outer rail. Two 50-ton jacks were started, one on either corner of the shovel frame, canted to draw the whole body of the shovel toward the center of the track. As soon as the body was free of the bolster, two 25-ton jacks were started at the corners of the journal boxes. As soon as the wheels were clear of the rails, the frame gradually settled, dropping the wheels in place.

The Lumber Situation

From a circular of the American Forestry Association we quote the following:

We are consuming lumber three times as fast as we are procuring it.

Experts predict our saw log lumber will be gone in 50 years.

The bulk of the original supplies of yellow pine in the South will be gone in ten years and within seven years 3,000 manufacturing plants there will go out of existence.

White pine in the lake states is nearing exhaustion and these states are paying $6,000,000 a year in freight bills to import timber.

New England, self-supporting in lumber 20 years ago, now has to import one-third of the amount used. It has $300,000,000 invested in wood and forest industries, employing over 90,000 wage-earners.

Fire destroys over $20,000,000 worth of timber every year and kills the reproduction upon thousands of acres of forest lands.

Within 50 years our present timber shortage will have become a blighting timber famine.

Forests can be protected from fire, regrowth can be encouraged, conservative cutting can be practiced, reforestation can be accomplished—but it takes from 50 to 100 years to mature a timber crop.

Forest devastation must be stopped, lands now in forest must be kept continuously productive, forest lands now devastated and idle must be put to work.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

W. Sinnott, 116 Seventh St., Springfield, Ill. has 6 teams idle.

E. Cutler, Nevada, Mo., has a 10 team and wheeler outfit idle.

M. C. Burke, of Burke Bros., died at Ft. Smith, Ark., last Tuesday.

B. F. Brooks & Co., Eastland, Tex., have 20 teams, machine and fresno idle.

A. Waddell secured the contract for stripping a shale pit near Ft. Scott, Kan.

S. H. Gibson, Newgoshen, Ind., reports his 10 teams and shovel outfit idle at Terre Haute, Ind.

Henry Schweitzer secured contract for stripping a coal pit and doing some road work in Southern Illinois.

J. J. McInerney is about through with his job at Ellet, Ohio. Wants any kind of grading in this part of the country.

Cameron, Joyce & Co., Keokuk, Iowa, were low bidders on a number of State Road jobs at Springfield, Ill., on April 12th.

Lynch & McDonald were low bidders for constructing the water works, reservoir and four miles of pipe line at Moberly, Mo.

Columbus S. Jones, the boss stationman, took a run down to Honduras to look over some railroad work. Returned without taking any.

J. W. McMurray Constructing Co. of Kansas City secured the contract for building a bridge across Turkey Creek channel in Rosedale, Kan.

Mrs. L. S. Cooper & Sons, Sims, Ill., have about finished their road work. Would like to place their team outfit on some grading in this neighborhood.

Contractors when in want of work or labor for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, or 501 Delaware St., Kansas City, Mo.

Ed. Molinger of the General Contracting Co., 357 W. 63rd St., Chicago, Ill., is scouting around hunting up work for a 20 team, wheeler and machine outfit.

Jack Carroll was with us a day. Jack reports his levee work in Southern Illinois getting along fine. Has had an elegant winter and piled up some nice estimates.

Peterson, Shirley & Gunther of Omaha were awarded a contract by the New York & Cuba Refining Co. to construct 50 miles of railroad for them in eastern Cuba.

Chas. C. Crawford, Anna, Ill., was here the other day trying to buy or rent 5 No. 1 wheel scrapers. Wants to use these on finishing a levee in Southern Illinois.

The Board of Public Service in a meeting at the City Hall voted to advertise at once for bids on paving projects which, it is estimated will cost $230,000. Improvements in this and two other calls for bids aggregate $705,000.

A. E. Howard, 430 S. Chicago St., Lincoln, Ill., has a part of his outfit at work on Federal road there. Howard writes that he has a new bridge and culvert outfit idle that he would like to place on work in Illinois, Missouri and Tennessee.

The work of grading [illegible] miles of the [illegible] County, Illinois, for which purpose [illegible] will be started immediately according to [illegible] County Superintendent of Highways D. O. Thomas at Belleville.

Work has begun on the first hard [illegible] leading out of Moberly, Mo., by the Moberly Paving Brick Co. It will be 18 feet wide and the foundation will consist of [illegible] concrete base with an inch sand cushion. On this will be [illegible] vertical fiber paving blocks with asphalt filler.

It is with extreme sorrow that we learn of the death of our old friend Harry Clapp in San Diego, Cal. There are very few of Harry Clapp's kind left which makes us sit up and take notice whenever we lose one of them. Funeral service where held at the West Side Masonic Temple in Chicago Saturday, April 16th.

The Decatur Water Supply Co. was granted a certificate of convenience and necessity by the Illinois State Public Utilities Commission to construct and operate a water works system in that city. The commission also authorized the company to issue $999,000 of preferred stock and $1,000 of capital stock of no par value.

Three bids for the construction of the St. Charles rock road from Taussig avenue to the St. Charles bridge, a distance of about two miles, have been received by the St. Louis County Court at Clayton. The lowest bid received was from the William McDonald Construction Company, which offered to do the work for $61,666.88, about $5,000 lower than the estimate of the county and state engineers. The other two bidders were the J. E. Perkinson Construction Company and the Louis Rich Construction Company.

The Axelson Machine Co. of Los Angeles, Cal., one of the oldest and largest machine companies in the West, has recently acquired approximately six acres of ground in South St. Louis on the Oak Hill branch of the Missouri Pacific R. R. between Walsh and Eichelberger streets, extending to Ulena street on the south, where it will erect a new plant costing $250,000. The company manufacturers high grade oil well pumps and supplies and the first unit of the plant to be constructed will contain the machine shop, forge shop and heat treating shop. The designing of the plant has been given to the Quidmer Engineering Co. of St. Louis.

Personals

W. L. Jepson has been appointed city engineer of Niagara Falls, Ont.

A. O. Rendell has been appointed city engineer of Rhinelander, Wis.

C. T. Jackson has been appointed district engineer of the Southern District of the Chicago, Milwaukee & St. Paul Ry., with headquarters at Chicago, Ill., vice D. C. Fenstermaker, having been granted a leave of absence.

S. M. Williams, chairman of the Federal Highway Council, announces the election of four new members to the executive committee of the council: W. J. L. Banham, general traffic manager, Otis Elevator Co.; David Beecroft, president, Society of Automotive Engineers, and directing editor, Class Journal Co.; Col. H. W. Alden, vice president, Timken-Detroit Axle Co., and S. P. Leeds, president, Atlantic City Chamber of Commerce.

F. C. Hoskins, who has recently been promoted to superintendent of the Baltimore division of the Baltimore & Ohio R. R., became identified with that railroad on Aug. 1, 1907, as bridge draftsman. He became assistant engineer in the bridge department later during the same year, being made assistant division engineer of the Pittsburgh division on Mar. 1, 1911. He was advanced to division engineer of the Connellsville division April 8, 1914, afterwards occupying the same position on the Philadelphia division, being advanced to superintendent of the Ohio River division at Parkersburg, Mar. 1, 1916. He has since been in succession superintendent at Wheeling, assistant superintendent at Pittsburgh, general agent at Baltimore and, since June 1, 1919, superintendent of the Baltimore Terminal division.

Industrial Notes

J. E. Tracy, for the past four years general sales manager of The Sterling Motor Truck Co., of Milwaukee, Wis., became actively connected on April 1 with the Hicks-Parrett Tractor Co. of Chicago Heights, Ill., in the capacity of vice-president and director of sales.

The Brown Hoisting Machinery Co. of Cleveland, O., announces the opening of a southern office, to be located at 530 Whitney-Central Bldg., New Orleans. The states of Texas, Louisiana, Mississippi, Alabama, Georgia and Florida will be covered from this office. Charles H. White, who has been with the Brown Hoisting Co. for a number of years, is manager of the new office.

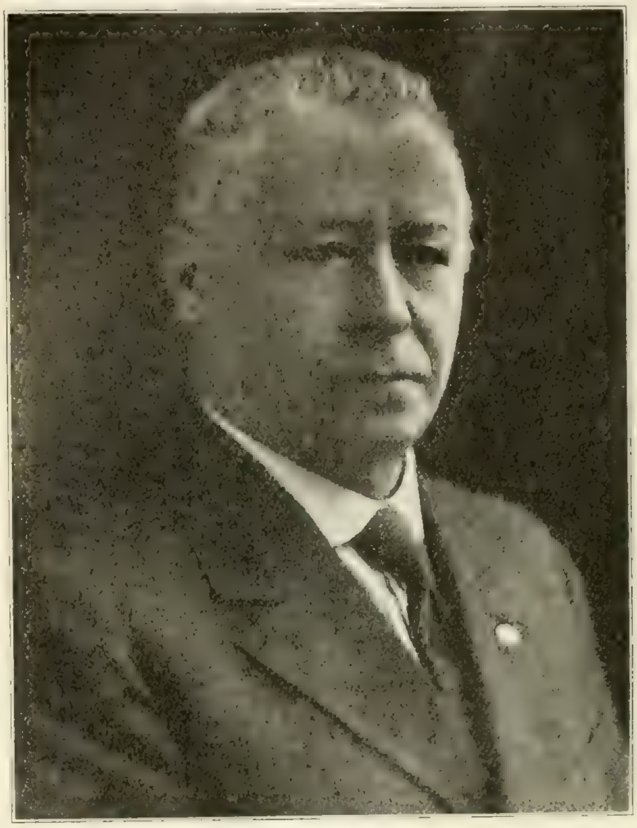
Obituaries

August D. Cook, president and founder of A. D. Cook, Inc., Lawrenceburg, Ind., died March 28.

J. R. Resch, formerly assistant engineer of the Texas & Pacific Ry. in Fort Worth and later division superintendent and chief engineer of the International & Great Northern Ry., died recently at Mart, Tex.

H. Kirke Porter, aged 81, Pittsburgh's pioneer locomotive builder, president of H. K. Porter Co., former member of Congress and for many years active in industrial and civic movements, died April 10 at his residence, 1600 I St., Washington, D. C. He, with a natural taste for mechanics, studied for and selected the business of a builder of light locomotives. His father had also been a locomotive builder, though he was for years prominent as a member of the old firm of Dilworth, Porter & Co. The firm was Smith & Porter from 1866 to 1871, when Arthur Bell came into the company and the firm was known as Porter, Bell & Co. In 1878 the designation was changed to H. K. Porter & Co., and so remained until 1899, when it became the H. Kirke Porter Co., with Mr. Porter as president. He took a turn at politics in 1902 and was elected a member of the Fifty-eighth Congress. He was selected as a representative of elements which protested against much of the old political order of things. He had but one term, but in that one term he impressed himself influentially on his colleagues. He was a member of many charitable and religious organizations.

Hiram A. Clapp, for many years a prominent factor in the heavy construction field, died April 11 at San Diego, Calif. For over 40 years he had been engaged in the construction labor and equipment business. During this time it is estimated that he furnished over 150,000 laborers for construction operations. "Harry" Clapp was born in Delphi, Ind., on Feb. 11, 1853. He established a labor agency in Chicago in 1880. About 30 years ago he moved his of- [illegible] the Western Wheeled Scraper Co., the Davenport Locomotive Works, and the Bucyrus Co. Later he organized the Clapp, Norstrom & Riley Equipment Co., of which he was president, and which still occupies the offices on South Canal street. He was a member of Siloam Lodge, No. 780, A. F. and A. M., a 32nd degree Mason, being a member of Oriental Consistory and a Noble of the Mystic Shrine, Medinah Temple. Siloam Lodge had charge of the funeral arrangements, which were held from the lodge rooms, West Side Masonic Temple, Oakley and Madison streets, Chicago, April 16, the pall-bearers being H. F. Riley, Gus Norstrom, E. M. Hall, S. M. Boorhem, L. H. Dimich and H. E. Scott, all business associates. He leaves a widow, a daughter, Elizabeth Clapp Ladenson, and a son, Hiram Robert Allen Clapp.



Hiram A. Clapp.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Continuous Rail Frog.—Jordan's Continuous Rail Frog Co., P. O. Box 735, San Francisco, Calif. Circular describing a continuous rail frog patented recently.

Dump Cars.—Continental Car Co. of America, Louisville, Ky. Catalog illustrating and describing Continental dump, mine, quarry, stone and industrial cars.

Surveying Instruments.—Wm. Ainsworth & Sons, Denver, Colo. Bulletin illustrating and describing this company's line of railway and highway transits and levels.

Pneumatic Hammer Drill.—Chicago Pneumatic Tool Co., New York City. Bulletin illustrating and describing B. Q.-46 hammer drill used in demolition work, street railway work, etc.

Excavating Machinery.—Buckeye Traction Ditcher Co., Findlay, O. Two circulars, one on the Model C Buckeye excavator, chain and bucket type; the other on the 4A wheel-type excavator.

Dragline Cableway Excavators. — Sauerman Bros., Chicago. Booklet illustrating and describing application of Sauerman dragline cableway excavators to handling earth, clay and sticky materials.

Excavator—Keystone Driller Co., Beaver Falls, Pa. Bulletin illustrating and describing Keystone traction excavator—a light steam shovel equipped with three different buckets, skimmer, ditcher and clamshell.

Gunite in Mine Work—Cement Gun Co., Inc., Cornwells, Bucks Co., Pa. Bulletin containing reprint of an article from the Michigan College of Mines Alumnus describing use of gunite in preventing slabbing in the Calumet and Hecla Mines.

Compressors.—Chicago Pneumatic Tool Co., New York City. Bulletin containing description of Chicago pneumatic oil engine driven compressors, together with interesting applications. Contains comparison of operating costs versus steam driven compressors.

Tractors.—Holt Manufacturing Co., Peoria, Ill. Ten bulletins devoted to performance of caterpillar tractors. Titles of some of these bulletins are: "Tractors for Moving Dirt With Elevating Graders"; "Tractors for Transportation"; "Tractors for Moving Dirt With Wheel Scrapers"; "Tractors for Road Maintenance"; "Tractors for Moving Dirt With Blade Graders." Other bulletins illustrate and describe use of tractors in the oil field and road building.

Rock Excavating Equipment.—Sullivan Machinery Co., Chicago. Three bulletins. One describes the new Sullivan Class B light weight drill sharpener, as well as the standard Class A machines with especial reference to the making of genuine double taper bits, etc. The second is devoted to angle compound air compressors, including mention of the company's single stage or duplex angle machines for low pressure. The third illustrates and describes Sullivan mine car compressors operated by electric motor for use in rock removal underground in coal mines particularly.

Building and Structural Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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New Location of E. & C.

On May 10 the editorial and business offices of Engineering and Contracting, which for the past 10 years have been located at 608 South Dearborn street, Chicago, will be moved to larger quarters in the Madison Terminal Bldg., 9 South Clinton street (corner Clinton and Madison streets), Chicago. The new location is close by the Chicago & Northwestern Ry. passenger terminal, is within 3 minutes walk of the Union Station and only a few blocks from the business center of the city.

The Engineer as a Political Economist

Practically all books on political economy have been written by men who have not applied the principles that they have expounded. The first noted English political economist was Adam Smith, a teacher, and most of his literary descendants have also been teachers rather than practitioners.

In other branches of science the reformers have usually been practitioners, and where they have been teachers they have usually had practical experience also. May we not infer by analogy that political economics will be developed into a true science by men who practice economics?

In his "Philosophy of Discovery," written in 1856, William Whewell says:

> I have already noted, in my "History of Science," that the indistinctness of ideas, which was long one main impediment to the progress of science in the middle ages, was first remedied among architects and engineers. These men, so far at least as mechanical ideas were concerned, were compelled by their employments to judge rightly of the relations and properties of the materials with which they had to deal, and would have been chastised by the failure of their works if they had violated the laws of mechanical truth. It was not wonderful, therefore, that these laws became known to them first.

As one example he cites the discovery of the most general law of the lever by Leonardo da Vinci (1442-1520), "the celebrated painter, who was also an engineer." In illustration of da Vinci's philosophical ability Whewell quotes from him as follows:

> Theory is the general, experiments are the soldiers. * * * We must consult experience, and vary the circumstances till we have drawn from them general rules, for it is she (Nature) who furnishes true rules. * * * In the study of the sciences which depend on mathematics, those who do not consult nature, but authors, are not the children of nature, they are only her grandchildren. * * * Nature begins from Reason and ends in Experience; but for all that, we must take the opposite course—begin from the experiment and try to discover the reason.

Evidently da Vinci anticipated, by a century, many of Francis Bacon's maxims. We are, however, not concerned as to da Vinci's philosophy. What we wish to call attention to is a fact that Whewell was perhaps the first to note, namely, that the greatest progress in scientific theory usually is attributable to scientific practitioners. Applying this generalization to the science of political economy, may we not expect to see economics brought to a higher degree of excellence by the efforts of engineers than by the efforts of professed political economists?

Indicative of an affirmative answer to this question are three noteworthy facts: First, that the literature of the science of management has been almost entirely written by engineers. Second, that the same holds true of the literature on public utility appraisals and rate making. Third, that the same holds true of the literature on cost keeping and cost analysis. These three branches of economics are vital parts of any comprehensive system of social management—i. e., political economy. Remember that the word "economy" originally meant "household management," and that the ultimate aim of political economy is the scientific management of that great household called the nation.

The number of professional engineers in America probably exceeds 200,000. They form the only large body of scientifically trained men other than the physicians. Engineers are in public employ to a larger extent than any other class of educated men. To them is entrusted most of the gathering and analyzing of economic data relating to public works and public utilities. They have been forced to apply the facts that they have collected and the theories that they have originated.

When the Literary Digest took a poll of its readers before the last presidential election as to the man best fitted for the presidency, an engineer, Herbert Hoover, received the greatest number of votes. That was the [illegible] of the educated people of America, and the sentiment it expressed is significant.

The Undertaker as Commissioner of Public Health

Office.	Regular Occupation of Office Holder.
Assistant Chief Engineer, Sanitary District of Chicago	Hoisting Engine Operator and Union Official
Head of Police Department	Laundryman
Head of Police Department	Hay and Feed Merchant
Head of Police Department	Ice Man
Head of Police Department	Coffee Salesman
Commissioner of Health	Harness Maker
Commissioner of Health	Undertaker
Commissioner of Streets and Bridges	Horeshoer
Commissioner of Streets	Groceryman
Commissioner of Public Utilities	Barber
Commissioner of Finance	Typesetter
Commissioner of Parks and Sanitation	House Mover

Of the above list, the first is the appointment of Mr. Edward F. Moore, against which the Western Society of Engineers has just protested. The other cases are tabulated from an article by Mr. Raymond B. Fosdick in The New Republic, of April 6. Only two of them were in cities of less than 100,000 population and none was in a small town. We could add to the list, for this is by no means our first protest against such incumbency, but more examples are unnecessary. Nor is logic needed: the impropriety (barring only most exceptional cases) is self-evident. Yet the practice goes on. The indifference of voters, and the indifference and dishonesty of some politicians seem to be all that perpetuate it. It will be remedied when (and not until) a majority of voters becomes aggressively conscientious.

The problem is obviously but a part of the larger one of arousing public consciousness of the fact that we are all paying for the waste of present political methods, and paying heavily—whether directly or indirectly.

We quote from Mr. Fosdick's article, in which he satirically suggests some of the exhibits which America might make at a World's Exposition of Democracy.

> We should have to find some way, too, in this exposition, of portraying the political fears and superstitions which we have inherited from frontier conditions of life, and our determined prejudices against an "office-holding class" which have been handed down as part of the Jacksonian fetish, and which, by limiting tenure of office and writing into the laws all sorts of provincialisms, make it impossible to place the administrative service of the specialized departments of government on a permanent expert basis. This could be illustrated perhaps by charts showing that whereas London has had seven police commissioners in ninety-one years, New York has had twelve in nineteen years, while Chicago has had twenty-five superintendents of police in forty-nine years. Charts could be used, too, to show that where London kept Sir Edward Henry as commissioner of police for fifteen years, Sir Richard Mayne for thirty-nine years, and Sir Edmund Henderson for seventeen years, we kept Arthur Woods in New York a little over three years, while L. T. Steward in Chicago lasted two.
>
> As a matter of fact our exhibit in such a world's exposition of democracy would undoubtedly show the United States on a lower plane in point of local government than [illegible] civilized country in the world, ranking far behind England, France, Germany and Austria, and in many respects behind Italy and Spain.

In conclusion we quote the action of the Western Society of Engineers on the appointment of Mr. Moore:

> The board of directors of the Western Society of Engineers, in the matter of the qualifications for the position of Assistant Chief Engineer of the Sanitary District of Chicago, has approved the recommendations of the public affairs committee, as follows: [illegible] public affairs committee [illegible] protest on [illegible] of Mr. Moore be sent to the [illegible] trustees of the Sanitary District of Chicago; that the office of assistant [illegible] be filled by a professional engineer selected [illegible] qualifications and [illegible] should [illegible] as technical [illegible] chief engineer and able to assume his duties if necessary.

Smoke

At this season, when the W. C. T. U. and Associated Powers are making their annual drive to deflate the tobacco business, our thoughts very naturally turn to smoke. We look out of the 17th story window at as much of the landscape as is visible, and have no need of a reminder that we live and work in one of the three dirtiest cities in America Pittsburgh, Cleveland, Chicago.

But not all is dark. Certain buildings in the loop are emerging from their annual, or biennial, face washing with countenances shining. The love of cleanliness still lives. This is a healthy sign, but it is not of the beauty or the morality of cleanliness that we would speak, for frankly, we do not believe that these will be the main considerations in inducing better things.

The problem is economic. What is the cost of bathing a skyscraper? How much greater is the cost of window cleaning in a smoky than in a smokeless city? What is the annual avoidable loss due to dirt in office and store and home? How many good carbon clad B. T. U.'s drift out of the stack—first, to obscure the atmosphere, and then to settle on your clean collar, or perhaps to take up an expensive abode on your wife's spring hat? How many costly tons of coal are wasted in isolated and inefficient plants? How many extra kilowatt hours run through your meter near the ends of the day because of darkened and dirty windows? What is the sum-total of these and other smoke costs? And what would it cost to eliminate them?

A careful study would bring an approximate answer to these last two questions; and both expert and popular opinions are that the cost of reduction would be less than the cost of smoke. If the city government cannot or will not take steps in this direction, could not those most affected profitably co-operate in an investigation and subsequent action. That some who ought would refuse to join the co-operative effort is to be regretted, but this would not reduce the benefits to accrue to their broader minded neighbors.

A Chicago daily prints at the head of its editorial column its six-plank "Platform for Chicago," and the first plank is "Lessen the Smoke Horror."

Minnesota Cities to Do Zoning Under Police Power

The State Legislature of Minnesota has just passed an Enabling Act and the governor has signed it, making it possible for Duluth, Minneapolis and St. Paul to do zoning under the police power. The act is as follows:

> For an Act to authorize the regulation of the location, size and use of buildings in cities of the State of Minnesota now or hereafter having 50,000 inhabitants or over, and the adoption of comprehensive plans pursuant to such regulations.
>
> Be it enacted by the Legislature of the State of Minnesota:
>
> Section 1. That for the purpose of promoting the public health, safety, order, convenience, prosperity and general welfare, any city in the State of Minnesota now or hereafter having 50,000 inhabitants or over, acting by and through the governing body of such city, may by ordinance regulate the location, size and use of buildings therein, may make different regulations for different districts thereof, and may acquire or prepare and adopt a comprehensive city plan for such city or any portion thereof for the future physical development and improvement of the city, in accordance with the regulations made as aforesaid, and may thereafter alter said regulations or plan, such alterations, however, to be made only after the affirmative vote in favor thereof of two-thirds of the members of the governing body of such city.
>
> Sec. 2. The governing body of any such city is hereby authorized to pass ordinances for the enforcement of the provisions of this act and of the regulations of such governing body under this act, and to provide, in any by such ordinances, penalties for violation thereof. Such governing body is also hereby authorized to enforce its regulations under this act by mandamus, injunction or any other appropriate remedy in any court of jurisdiction thereof.
>
> Sec. 3. In any such city having a city planning commission the provisions of this act shall be construed as an addition to existing powers and not as an amendment to or repeal thereof, and the governing body may adopt a plan or plans prepared by such city planning commission.
>
> Sec. 4. This act shall also apply to any city of the first class in the state operating under a home rule charter adopted pursuant to Section 36, Article 4, of the state constitution.
>
> Sec. 5. This act shall take effect and be in force from and after its passage.

Action of Sea Water on Concrete

To the Editor: The action of sea water on concrete, taken from a report of an investigation made to determine the effects upon concrete piers in the U. S. Navy Yard at Charlestown, Mass., and printed in your issue of March 23, is both interesting and instructive.

The writer knows of concrete ways, the ends of which were exposed in about the same manner as described in your article, that have been laid about four years and that would correspond to the condition of the piers mentioned as of Dec. 17, 1913.

The concrete for these ways was mixed with sea water and of wet consistency. The proportions were 1:3:5.

Today, they are in very good condition with no barnacles attached, and as there has never been any crude oil floating on the water around them, the writer does not think that we can give the crude oil the credit for the absence of barnacles. We must look for some other reason.

The report in your March 23 issue shows that the wet mixture in the proportions of 1:1:2 has stood up the best, and the writer's experience has been that it is absolutely necessary to have enough cement to completely fill all of the voids in the sand, and to see that it is properly mixed, in order to get the best results for concrete in sea water.

Dover, N. H. WALTER S. WHEELER.

The Value of Short Reports

The art of stenography, the recording dictagraph, and the typewriting machine are to blame for many troubles. It is a bother and a labor to write long-hand, and it is much easier to talk. And a great many of us do talk too much. The troublesome business of long-hand writing and the cost of printing a limited number of reports had the salutary effect in days gone by of inducing us to number our words. Nowadays the busy man gets too much to read. Newspapers are plastered over with useless "Bed Time Stories" and other mush, or news items carried over from a few inches of space on some other page, to provide that advertisements may be "next to reading matter." Nobody wants to learn how little Willie saved a robin's egg, and the inspiring fact that Cordonnier, Schuster & Shoemaker are having a great sale of boots and shoes, all at the same time.

The burden of complaint, however, is with the vast quantity of text that has to be read. Every professional man knows the task of keeping up with his profession, and we admit frankly that it is our business to add to this burden. His daily newspaper is almost a miracle of inconvenience, as far as an orderly presentation of the news of the day is concerned. His daily mail contains as many if not more circulars of tailors, automobile dealers, appeals, etc., which he throws away unread, than it does of actual communications which call for his attention.

The engineer or business man with his technical or trade paper has less to do than the professional man, but if he is a live wire he has still a great deal to read.

Then comes a report on something he wants to know. If he wants an exhaustive treatise he is likely to say so beforehand, but unless he calls for it he doesn't want it. If it is too long he gives a sigh and digs in for a few minutes, and then puts it into his basket of unfinished business. He takes it home with him at night, and loses patience over having to wade through information that he does not want. Then the chances are that he will turn to the summary and reach his conclusions from that, being a little nettled over the fact that he did not get what he wanted earlier.

When he goes to his lawyer he is not charged for the length of the interview: it may last 15 minutes the first visit, the lawyer may work two weeks over the problem and then telephone the one word "Don't." But his counsel fee will not be nominal.

With no suggestion that reports of research of any kind shall be superficial, we make the plea for conciseness in technical reports whenever this is possible. All details should be duly annexed and speedily available, but the reports themselves should measure up to the novelist's rule: "First catch the reader, and then hold him."—Editorial in Chemical and Metallurgical Engineering.

Steel Prices

Steel prices having been equalized and stabilized—equalized as between the Steel Corporation and the independents, and stabilized in that further changes of consequence are not expected in the near future—comparisons are in order.

Comparisons of steel prices today with those of other times can well be made on the basis of merchant steel bars, for investigation shows that bars are typical of steel prices in general. Steel commodities that have shown materially different percentage advances and declines from those of bars are products that have been affected by special conditions.

Bars are now 2.10 ct., which in comparison with the 2.35 ct. price in the Industrial Board Schedule, shows a decline of 11 per cent and compared with the war control price of 2.90 ct. shows a decline of 27 per cent. As for comparisons with a "pre-war average," an interesting point is that it makes little difference what sort of a period is taken. If one takes the 10 years, 1904 to 1913 inclusive, he finds an average of 1.40 ct. If he takes only five years, 1909 to 1913, his average drops to 1.33 ct.; while if he takes only 1913 his average goes up to 1.38 ct. if forward deliveries are taken, or to 1.55 ct. if prompt deliveries only are considered. One cannot go far wrong, then, in taking 1.40 ct. as a very fair pre-war standard, and from that price the present 2.10 ct. is an advance of precisely 50 per cent.

Similar comparisons with many of the other steel products would give about the same showing, a 50 per cent advance over the pre-war standard. A few commodities would show a greater advance, for some special reason. Thus sheets show a greater percentage advance, fairly attributable to the large amount of labor involved in their production. Hoops and bands show an advance of about 70 per cent.—From an editorial in The Iron Age.

The Housing Shortage in the United States

At the present time over 1,000,000 new houses are needed in the United States, according to the report of the Calder Committee, submitted last month to the U. S. Senate. The conclusions of the committee are based on the following:

In 1890, according to a statement quoted by the U. S. Housing Corporation, there were 110½ families for every 100 homes: in 1920 there were 121 families for every 100 homes. According to the Bureau of the Census, in 1890 52 per cent of the people were tenants and in 1920 the record may show that 60 per cent of the people are tenants.

The Bureau of the Census is reported as giving the normal yearly residential construction as 310,000 structures. However, assuming a higher figure, as estimated by some authorities, of 400,000 structures, it has been estimated that at least one out of every five new habitations erected must be utilized to take the place of losses through fire, obsolescence, or alteration for other than residential purposes; so that out of the estimate of 400,000 new habitations as the yearly normal, but 320,000 remain under normal condition to take care of the need for new homes due to increase in population through immigration, births, and marriages. Assuming that these habitations on the average accommodate five people each, they would furnish accommodations for about 1,600,000 people annually, or about 1½ per cent of the present population.

However, it is estimated that residential construction from 1915 to 1918 was but 42 per cent of normal; in 1919 it was 58 per cent of normal, and in 1920 it was but 37 per cent of normal. These estimates are made on square footage and not on dollar valuations.

According to these estimates the shortage during the past six years has increased to slightly over a million habitations; and if the rate of construction during the past six years should continue until 1926, the shortage will be in the neighborhood of 2,000,000 habitations.

State Legislatures and the City Manager Movement.—According to the March Bulletin of the City Managers' Association the legislatures of Indiana and Wyoming have passed state-wide optional bills granting all cities in these states the privilege of adopting city-manager government by referendum. The Illinois effort has again been postponed, and the New Jersey bill is now before the legislature with a fair chance for passage. In California a bill is before the legislature authorizing any city in the state to provide for the appointment of a city manager by ordinance introduced and adopted under initiative.

Book Reviews

"Shades and Shadows," by [illegible] Architecture in the Washington [illegible] John Wiley & Sons, New York. [illegible]

Here is a meritorious little work setting forth in clear fashion the principles of descriptive geometry and of shades and shadows. The author has followed consistently his prefatory announcement of due consideration to the engineering point of view. "The information contained herein was compiled with special attention for its use as a text book on shades and shadows. Architectural students in many colleges receive their early training under engineering teachers. An attempt was therefore made to serve such students, by assuming the point of view of their engineering training at the beginning of the book, and lead them by a study of shades and shadows toward an appreciation of the artistic architectural point of view, so seldom developed in a strictly engineering course."

It is to be regretted that the artistic viewpoint thus sought to be established is imperfectly exemplified at the very opening of the book by a bad arrangement of the frontispiece on the page. There a picture (pleasing in itself) is placed upon a sheet to which it is so badly proportioned that even an untrained eye can not well overlook the defect. At other places small bits of printed matter are given a similarly bad arrangement, awkward blank spaces appearing both above and below the type. We do not mean to overemphasize these defects, but where one aim is to stimulate the sense of the artistic they are not insignificant.

The illustrations are very numerous and adequately present the methods of descriptive geometry and shades and shadows. A number of very pleasing architectural drawings—some of them the work of students—illustrate the applications of the methods and lend attractiveness and interest to the work. Numerous problems are given at the ends of the various sections. The final section treats briefly of wash-rendering—a subject on which there is the following interesting comment in the forepart of the book: "They often resort instead to mere copying, to the use of shades and shadows merely guessed at, and to a lavish rendering to cover mistakes. The beauty and impressiveness of a drawing is more truthfully enhanced by the accurate casting of its shadows than by its rendering."

Structural Steelwork, by Ernest G. Beck, Assoc. M. Inst. C. E. 462 pages, several tables; 300 figures. Longmans, Green & Co., London and New York. 1920. $7.50 net

The book is a reference and text "relating principally to the construction of steel-framed buildings." About the method of the book, the author says in his preface: "The aim has been to keep the physical realities clearly in view, and to make each expression a simple and explantory record of some real and easily understandable operation, state or change."

In pursuit of this aim the author gives a very clumsy definition of the modulus of elasticity (page 3): "The modulus of elasticity may, therefore, be regarded as a hypothetical stress, which is constant for each material, and of magnitude equal to that which would result from increasing any stress (within the elastic range of a particular material) in the ratio borne by the original length of a bar (of that material) to the alteration in length corresponding to the particular stress selected."

The section modulus, moment of inertia and radius of gyration are presented as lever arms of a couple, the moment of which is equal to the resisting moment of the section, and the parallel forces equal to various functions of the extreme fiber stress.

The chapter on columns with axial loading contains excellent discussions of end conditions, effective length and long columns in addition to a presentation of the column formulae of Euler, Gordon and Rankine, and Fidler. It is interesting to note that the Rules of the London County Council specify a straight line formula, or rather a broken line formula: one line for values of l/r below 100; another for values of l/r above 100. The maximum allowable values of l/r for columns with both ends hinged is 140; with one end fixed and one hinged is 180 and with both ends fixed is 210.

Columns braced in groups and laterally and eccentrically loaded columns are treated very completely, although too theoretically. The chapter on the design of columns has many numerical examples and abounds in discussions of details.

A small chapter is devoted to beams and girders. A more complete treatment was reserved for a later book.

About one-half of the book is taken up by Roof Trusses, of which most space is devoted to Bracing. Chap. IX, Roof Trusses with Knee-Braces; Chap. X, Examples of Knee-Braced Roof Trusses; Chap. XI, Roof Trusses with Knee-Ties and Chap. XII, Multiple Bay Knee-Bracing. Of the remaining two chapters in the book, one shows methods for analyzing stresses due to dead and wind loads, while the other takes up the design of roof framing. In this connection it is worthy of note that the author avoids stating any formula for the normal component of the horizontal wind force. He mentions that "some designers take the full horizontal wind pressure as acting on the vertical propected area of the roof," "but the forces which it gives are excessive in ordinary cases." This is equivalent to using a normal wind force N equal to W Sin α where W is the horizontal wind pressure and α is the inclination of the roof with the horizontal. The forces obtained by this formula are usually smaller than those obtained by the formulae current in American practice. For instance Duchemia's formula is $N = \frac{W\,2 \sin \alpha}{1 + \sin^2 \alpha}$. Hutton's is $N = W(\sin \alpha)^{1.84 \cos \alpha - 1}$

The appendix contains tables of properties of Standard British Sections and a short table of logarithms.

While the book is badly balanced, giving too much space to bracing and practically none to beams and girders, it has certain merits making it very useful to the student and practicing engineer. The assumptions underlying the design of details and connections are stated clearly and discussed ably; limitations of formulae as applied to practical cases are usually pointed out—preventing the blind following of the formulae.

Red Lead and How to Use It In Paint, by A. H. Sabin, M. S., D. Sc. 139 pages and tables, diagrams and illustrations; third edition; rewritten and enlarged. John Wiley & Sons, Inc., New York. 1920. $2.00 net.

This is another valuable work by the author of "White-Lead: Its Use in Paint." Coming from so recognized an authority as Mr. Sabin this book ought to interest engineers and contractors in the study of the merits of red-lead as a paint.

The purpose of the book is stated in the preface: ". . . It seems to him (the author) that red-lead is not known as well as it should be; and particularly that the great advances made in its production and character need to be made use of more generally."

The author begins with a chemical study of red-lead, its manufacture and by-products. The history of the improvement of the product is given next. The great trouble about red-lead is its mixture with litharge, which makes the paint "ropy" and starts "runs," thus wasting paint and helping start corrosion. But the improvement in the manufacture of red-lead makes it possible to obtain a powder containing less than 2 per cent of litharge, eliminating the objections to red-lead as a paint.

The book contains practical suggestions for obtaining the best results and for increasing the length of service of the paint. A discussion of practical points in painting water tanks, standpipes, ships, railway cars, etc., is given. The author gives the arithmetic of red-lead mixing together with formulas for various coats.

Valuable information is contained in the appendices. Appendix I has: Method of Analysis of Red Lead of the A.S.T.M.; formulas to obtain various colors; diagrams giving volumes and compositions of paint; tables in American and British units giving handy data on composition, also cost of paint for various market prices of red-lead and oil. Appendix II contains specifications for painting bridges, ships, water tanks, gas holders and other steel structures.

The book is well written and makes easy reading; together with the wealth of information it contains it is recommended as a guide for engineers specifying red-lead paint for steel structures.

Readings in the History of Science

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The history of science furnishes fascinating reading for anyone of scientific or philosophical turn of mind. An engineer, for instance, can get a realistic conception of history's great sweeping movements, and can envisage the actual background of famous bygone periods, in no better way than by reading of early scientists and their relations to their environment. The reader should not confine himself to tales of practical inventions and to over-laudatory accounts of poor boys who climbed to eminence by working hard and doing no evil. Unfortunately, too many books of science history are of that kind. There are, however, truer and more human records of early scientists, though such records are scattered about and there is a lack of readable books written by men of scientific acumen. Such books as Sedgwick and Tyler's "A Short History of Science," Ball's "History of Mathematics," Andrew D. White's "History of the Warfare of Science with Theology in Christendom," H. S. Williams' "History of Science," John W. Draper's "History of the Conflict Between Religion and Science," and J. J. Walsh's "The Thirteenth, Greatest of Centuries," are typical of an increasing literature written by broadly educated scientists.

How helpful and suggestive to an engineer is a story of Galileo's accomplishments and difficulties. As Professor John F. Woodhall relates in a recent number of the General Science Quarterly, Galileo was a professor at twenty-five, on the faculty of the University of Pisa, at about the same time that a young man named William Shakespeare was seeking his fortune around the London theaters. Because of his inquiring and controversial spirit Galileo found his dogmatic colleagues impossible to live with, and he left Pisa in disgust; in fact he was practically driven away by their dislike and calumnies. Later, at the University of Padua, where he remained for 18 years, he lectured to audiences of a thousand and two thousand persons at a time, including distinguished foreigners who came from all over Europe to hear him. At 70 years of age, in 1633, 90 years after Copernicus had published his heliocentric theory to the world, Galileo, a frail old man, was haled before 10 red-robed Cardinals or "Inquisitors-General" and made to recant his teaching of the Copernican system, because the "Theological Qualifiers" ruled that the propositions that the sun is the center of the world and that the earth moves are "absurd, philosophically false, and formally heretical"!

Another sad scene in historical science was that of the burning in Manchester, England, shortly after the French Revolution, of the home of Joseph Priestly, Unitarian clergyman, because of his advanced views. Although Priestly had given to the world nearly 20 years previously the priceless discovery of oxygen, which is the "very corner-stone" of modern chemistry, the mob suspected him of radical political sympathies and, crying, "Church and King," smashed his chemical apparatus, looted his wine cellar, and burned his home and library. So unfair and small-minded was the England of that time that his friends in the Royal Society shunned him and the great Burke inveighed against him in Parliament. To the eternal credit of America, to which he emigrated in 1794, true hospitality was shown him and the University of Pennsylvania offered him, by a unanimous vote of the trustees, a professorship which, however, he did not accept. Later, he also declined the principalship of the university, and after 10 years of life in America died at the age of 71 in his peaceful home near the Susquehanna.

Italy of the Renaissance had a lively history. The story of Tartaglia and Cardan, two rival professors of mathematics, is typical of the strenuous times of the 16th century. Tartaglia as a small boy had been nearly killed in a massacre of citizens by French soldiers. The wounds that he received about the head injured his palate and made him stammer, hence the name Tartaglia or "Stammerer." He was so poor that he could go to school only 15 days; he stole a book in order to learn to write, and utilized tombstones as a slate for working out problems. When he invented an algebraic solution of cubic equations, his rival Cardan wheedled the secret from him and published it as his own, though he had promised not to. Cardan was an atrocious scoundrel, one of the most debauched villains in history, yet a brilliant scholar and a plausible and ingratiating talker. He gambled regularly, cut off the ears of his son, was probably a murderer, and is said to have committed suicide at 75 to fulfil a prophecy that he would die on a certain date.

Sir Isaac Newton was a better behaved scientist than the sarcastic Galileo, who ridiculed his narrow-minded colleagues; than Priestly, who argued for political reform; or than Cardan, who thrived on sin and was astrologer to the Pope. The son of a farmer, he was born in the year that Galileo died, went to the University of Cambridge, and remained there over 30 years. His lectures to the students consisted of dictation on new theories that he had originated. Ten short lectures comprised a course, and he never repeated a course, giving new ones each term. In his fifties he moved to London to be master of the mint, and was created a knight.

Other well-behaved but rather narrow scientists were: Cavendish, who lived like a recluse in London and died one of the richest men in England, after discovering hydrogen and determining the composition of water; John Dalton, the Manchester Quaker, who gave to the world the atomic theory; and Copernicus, the Polish churchman who feared to publish his heliocentric theory until he was dying. Cavendish lived an old-bachelor existence as a nephew of the Duke of Devonshire, dodging intercourse and avoiding looking squarely at anyone, though paying an occasional visit to the Royal Society. Dalton worked as methodically as any modern time-clock puncher; at the same hour each morning he repaired to his laboratory, taking a lantern in winter rather than change his routine. Copernicus changed the world's attitude toward itself, but feared to offend his superiors in office while he needed a position.

The method of working of any great accomplisher is always interesting. Of Charles Darwin, who revolutionized science, theology, and education, his son writes in the Dictionary of National Biography: "His day was parceled out into a number of short periods of work, interspersed with regular intervals of rest. Thus in the morning, and after some two hours in his study he would appear in the drawing room, look at his letters, and rest on the sofa while listening to a novel read aloud. Then after another short spell of work he would take his regular midday walk, and in the afternoon would follow a similar alternation of rest and work." How our modern strenuous makers-of-motions would ridicule a scientist who pottered around the house like this simple English gentleman. Yet his work will remain forever as one of the great influences of history.

Of Herbert Spencer, who accomplished great feats in philosophy, ethics, science, sociology, etc., Professor L. L. Bernard writes in the January Monist: "He thought in the same leisurely way in which he grew up intellectually. . . . His thinking . . . was almost wholly free from that drudgery and effort which characterize the novice and the relatively inefficient in thought. . . . In his youth Spencer was greatly given to day-dreaming. His later intellectual life partook largely of the same character, in so far as its subconscious spontaneity was concerned. . . . For a man who accomplished so much he spent an enormous amount of time in recreation. Most of the summer months were spent with friends in Scotland or Wales, or the English country side, with occasional trips to Paris, Switzerland, Holland, Italy, Egypt, and even, on one occasion, to the United States. . . . He spent most of his afternoons either in walking or at the club."

How wasteful of time this would seem to a modern efficiency expert, yet let such an "expert" look at the great shelf full of books that Spencer produced and then tell us what he (the "expert") has accomplished. Professor Bernard explains Spencer's method of thinking: "An idea once lodged in his mind was left largely to take care of itself while the owner of the mind went about the intellectual business in hand. The result was that a great deal of subconscious thinking, if one may use such a phrase, was done." Spencer's subconscious mind was revolving ideas while he walked, talked with friends, fished, or played billiards.

Descartes, the great French mathematician and the founder of modern philosophy, got some of his most fruitful ideas from dreams, and he is said to have invented analytic geometry one morning while lying in bed. Two of the greatest masters of research in modern science were Davy and Faraday, yet neither had a university education, and were sniffed at by the conventional scientists of their time. Pasteur, perhaps the greatest of all French [illegible] ed savagely by the physicians and [illegible] although the science of bacteriology which [illegible] of invaluable aid to the medical profession.

These suggestions for reading in the history of science are sufficient to indicate that many scientists of bygone periods were as human as one of us of today, that truthful accounts of their lives illuminate for us the curious misconceptions under which authority and convention labor, and that man's nature has not changed for thousands of years in spite of ups and downs, and fads and fancies. The history of science teaches history as well as science, philosophy as well as physics.

Cleaning Old Brick With Pneumatic Tools

A prominent engineering construction company recently adopted a novel method for salvaging old bricks left from alteration work on an old plant and necessary for use in a new structure. By using a Boyer chipping hammer made by the Chicago Pneumatic Tool Co., and fitted with extra wide faced chisels forged from stock blanks, they are enabled to clean 3,000 bricks per day at a saving of 75 per cent in cost over the previous average of 650 bricks per day by hand. The bricks were more uniformly cleaned than was possible with ordinary hand labor.

Chipping Hammer and Wide Faced Chisel.

The hammers used were, the Boyer, type BB, chipping and calking, 1 3/16-in. bore by 1½-in. stroke, consuming 12 ft. of air per minute. The blows delivered by the hammers were not too heavy to damage the bricks, yet sufficiently effective to remove all old mortar and dirt.

The work was accomplished on tables. About 100 bricks were cleaned at a time. The bricks were laid side by side on the table. When so placed the bricks formed a comparatively flat surface measuring 12x3 ft. This arrangement enabled the operator to clean 100 bricks before turning them for cleaning on the ends and other sides.

While the labor cost of 40 ct. per hour was the same as for hand methods, the pneumatic method cleaned five times as many bricks as were formerly cleaned in the same period of time by hand methods. The cost of compressed air averaged 2 ct. per hour per hammer. The cost per 1,000 bricks, hand cleaned, was $5.55; mechanically cleaned, $1.26.

Am. Soc. C. E. Progress Report on the Bearing Value of Soils

The following is a summary of the progress report of the Special Committee to Codify Present Practice on the Bearing Value of Soils for Foundations, presented to the annual meeting of the American Society of Civil Engineers held on Jan. 19, 1921.

Definitions of Soils.—The committee has given further consideration to definitions for soils that will combine common and practical ideas with controlling physical factors. The difficulty is emphasized, however, through the frequent confusion of the physical state of the soil material with the soil as a mass. For example: "Quicksand" is a physical state of water and granular material, rather than a type of soil.

Throughout the West there are a number of soils with which the members of the committee are not familiar, and they would like to hear from members of the western districts in order to include all soils of importance.

A general discussion of soils met with in construction work by members of the society might develop further suggestions for definitions. For this reason some common definitions of soil such as: Alluvium, Bog, Clay, Drift, Gravel, Hardpan, Loam, etc., are presented in the report.

Mineralogical Composition of Soils.—The committee has given further consideration to the influence of the mineral composition of soils. The failure of certain soils by decomposition or crushing of particles, has led to a fruitful field for study in the relation of the mineral composition to the physical factors. In this connection "sedentary" soils frequently retain the original minerals unchanged, whereas in "transported" soils the minerals present are those that most tenaciously resist wearing and weathering.

Mineralogically, the soil varies with its chemical composition; it may be calcareous, alkaline, ferruginous, inicallous, silicious, etc. The presence of oxidizable sulphides may cause heating and disintegration of the soil when exposed to the air. According to Dr. Donald F. MacDonald this happened locally in the Gaillard Cut, Canal Zone, Panama. It sometimes happens in coal and culm piles.

The leaching out of soluble sulphates or other salts may cause clays to disintegrate rapidly and slide. Calcareous material, if present, may also be dissolved out of clays, causing them to lose cohesion.

The following is a synopsis of a study, by Dr. G. N. Coffey, of 25 surface soils from the Costal Plain, Piedmont Plateau, and Limestone Sections of the United States, as found in Bulletin No. 85, U. S. Department of Agriculture.

Characteristics of Surface Soils.—A.—Arid soils have a large percentage of minerals other than quartz.

B.—Humid soils, with the exception of orthoclasse and microline, have less abundance of feldspars.

C.—The influence of topography on the surface soil is often very marked. In mountainous regions erosion allows only a thin mantle of soil to accumulate. The minerals show a very slight alteration indicating that weathering has not been acting for a very long period. In the plateau regions the surface is not broken, giving rise to less erosion, but more advanced decomposition.

D.—Limestone soils have little variations in minerals, and such as are present occur in very small particles.

E.—In the unconsolidated water-laid deposits of the Coastal Plain a high percentage of quartz is abundant.

F.—Soils formed from glacial material are characterized by a relatively large percentage of minerals other than quartz, especially in the sands. The grains are only slightly rounded.

G.—In loessial soils about 75 per cent of the soil mass consists of silt. The grains are mostly angular, with some fairly well rounded.

H.—The total number of minerals found in the 25 surface soils is 34, the average number present in a sample being a fraction more than 13.

J.—There appears to be a considerable variation of mineralogical composition. Soils usually have a greater variation than rocks, since they are the dispersed products of rocks through degeneration and decomposition.

K.—The characteristics of the different minerals are as follows:

Quartz is the most abundant mineral occurring in every sample. Quantitatively, quartz constitutes from 50 to 95 per cent of the surface soil, the average being 83 per cent, but it constitutes less of silt than of sand, indicating that a smaller percentage would be found in clay. The quantity of quartz is greatest in surface soils derived from rocks that have undergone the most attrition and decomposition.

Quartz occurs in largest quantities in the southeastern part of the United States.

Epidote is the next most common mineral, followed by hornblende and the two feldspars—orthoclasse and microline. The latter were not found in the reddish soils.

Of all the varieties of minerals, feldspar occurs next in abundance to quartz. The plagioclasse feldspars—labrodorite, andesine, oligoclasse, and albite—do not appear where the soil is subjected to the greatest leaching and attrition.

The micas—biotite and muscovite—occur rather frequently. Chlorite, zircon, tourmaline, and rutile are all common minerals, but are seldom abundant, the three latter being hard-weather resisting minerals.

The apparent reason for the small occurrence of the iron minerals—magnetite and hematite—in surface soils is due to the fact that organic matter attacks iron very readily. Iron is commonly found in rocks.

L.—A greater percentage of minerals is found in the north, due to the glacial action of grinding down of rocks containing various materials.

The Color of Soils.—The committee adheres to the statement made in a previous report that the color of the soil has a very limited physical significance. In deference, however, to the universally established habit of referring to color in describing soils, a simple procedure is here presented to ensure uniformity of practice.

Although the color of soils is influenced by the mineral composition, drainage, and content of organic matter, the time color is that which it possesses when exposed under field conditions. Soils that vary in color may be described as mottled

In positioning a soil in the color scheme, it is desirable to avoid precise variations. The method developed, however, introduces accurate comparisons by adapting the idea of whirling disks of various colors. Experiments determined the composition of 15 standard colors. These are sufficient for the range of ordinary soils.

Seven paper disks of standard colors were used. Each disk, 5 in. in diameter, is slit from the center to the circumference, in order to enable other color disks to slide between and expose the percentage of color desired. The percentages are obtained by markings on a 5½-in. disk, at the back. This enables a quick and ready adjustment of color disks adaptable to any color of soil.

The color disks have holes 2 in. in diameter in their centers, to fit over the clamps on the top flange of an open brass cup. In this cup is placed the sample of soil, and it is fastened concentrically with the shaft of a small electric fan motor. The color disks and sample are rapidly rotated by the operation of the motor in a horizontal position. The varying percentages of the exposed color disks and the color of the sample of soil are thus easily comparable.

Revised Soil Classification.—The committee submitted a revision of the proposed classification of soils to which has been added a further sub-division termed "colloids", for the determination of which a centrifuge of very high rotating speed is necessary (about 40,000 r.p.m.). The committee is not at present in a position to enter into details as to this class of material, but tension experiments conducted upon mixtures of the "colloids" and Ottawa sands have shown such surprisingly high strength as to indicate its great importance. In fact, it now appears that this element alone, or together with water, may account in a large measure for the cohesiveness of soils. The subject is to be further followed up by the committee, and reported on later.

"Structure" has been changed to refer to the arrangement of the soil mass on bedding, instead of the particles. It is an important factor.

"Porosity" is defined as the equivalent of density or percentage of total pore space. It is an important physical factor, and often determines whether the soil particles are arranged loosely or compactly.

The water in soils may be either of a permanent or of a temporary nature. The permanent water above the water table is due to surface tension and is the capillary water content. Its determination is very important, for it resists the action of gravity and cannot be drained. The constant "dampness" of soils is traceable to this characteristic. The size and arrangement of the pores and the texture of the soil have controlling influence over the quantity of capillary water present. Excess water, or the water of gravitation, is that which responds to the action of gravity and is flowing to a lower level. Such water will vary with the seasons. The phenomena of slides are frequently due to excess water content.

Revised Scheme of Classification.—The following sub-divisions of sedentary and transported soils are recognized as representing the first factor in the divisions of soil classification:

- Sedentary soils:
  - Residual (formed in place);
  - Cumulose (accumulated organic matter).
- Transported soils:
  - Colluvial, or gravity laid;
  - Alluvial, or water laid, by streams, lakes, or oceans;
  - Aeolian, or wind laid;
  - Glacial, or ice laid.

Mineral Composition.—This relates to the evident abundance of minerals in the composition of soils.

Structure.—This refers to the natural occurrence of the soil in beds, masses, pockets, or stratified in layers, and the dip of same, and occasionally by cracks, fissures, etc.

Porosity.—This refers to the arrangement of the particles of the soil. It is the density or percentage of total pore space, and is also an important factor.

Water Content.—This refers to the volume of pore space occupied by water. It is an important physical factor.

Texture.—This refers to the relative range ratio and mid-grain size, as determined from plotting the mass diagram of a granulometric analysis. It is constant and is recognized as an important factor.

Variations in the shape of particles may modify the textural class, such as, flat shaley, slaty, sharp, angular, rounded, corroded surface grains or fragments of rocks.

Definitions of Settlement, Allowable Load, Etc.—Settlement is defined as the change of horizontal plane of any part, or all, of a structure, occurring after the beginning of construction. Some settlement occurs before the completion of the structure, and some continues for a time after completion After reaching a state of rest, other work near-by may influence the soil bearing the structure and cause vertical motion again to take place. This may occupy but a short period of time, after which the structure again comes to rest. Such vertical motion, or settlement, is due to a number of causes. The excavation of the soil and the preparation of the bed of the foundation disturbs a portion of the grains at the surface of the soil, and they become somewhat loosely associated. The application of weight to soil in that condition naturally compresses it.

The building of the foundation has a tendency to compress the soil to, or even exceeding, the degree to which it was originally compressed. The addition of more weight to the foundation than that of the soil removed for its preparation at once increases the compressive stresses, and reduction of volume and consequent settlement take place up to the yield point of the soil for such compression. If the load is increased beyond that limit, displacement of the soil takes place due to the crushing of the grains, or actual movement of the grains from their original position. All these effects are accompanied by a settlement of the structure. In brief, soil acts in much the same manner as other elastic bodies, within certain limitations.

These different movements or compressions in any soil where it is possible to build without the use of piles, or in other words, where there is not an excess of water causing a more or less viscous condition of the soil, are illustrated by a fairly regular form of compression curve. Such a curve shows a relatively large compression at the beginning of the application of the load, diminishing rapidly as the load is applied, then a considerable increase of weight with a fairly regular compression, until finally rapid break-down occurs as displacement or crushing of the grains of the soil takes place.

Even in wet ground, and using piles, much the same form of compression curve is obtained. There is relatively little resistance at the beginning of the curve, increasing as the soil is compacted and the excess water is driven out. As the grains take an elastic bearing, there is a quite wide range of safe compression. This is lost on overdriving, because actual displacement of a considerable quantity of the surrounding soil results, which is thus somewhat restored to its original condition and further compression is necessary to develop its elastic resistance. The resistance is also often restored by a period of rest, during which there is a readjustment of the grains. Such a readjustment also takes place in the grains in the case where piles are driven by jacks, and it is found that if the jacks are released without restraining the piles, further penetration is necessary to secure the same degree of resistance. All these things point to a high dgree of elasticity of the soil considered as a mass.

Allowable Load.—The allowable load is, in most cases, determined by the question of settlement and the effect of such settlement on the proposed structure. It is obvious that for certain types of structures the settlement should be kept to an absolute minimum, because such settlement, or at least unequal settlements in different parts of the structure, will cause physical damage. For example: if a highly ornamental cut-stone building settled unequally in different parts, it might be much disfigured and injured by reason of spalling or cracking.

It is believed that the limit of allowable load should be based on some definite portion of that part of a compression diagram showing a practically uniform rate of compression with increase of load. The amount of such percentage should vary with the type and importance of the structure. Manifestly, structures such as reservoirs containing fluids, where settlement would cause cracking and leaks, should be limited to a much smaller percentage of the ultimate load than the column piers of an elevated railroad, isolated monuments, etc.

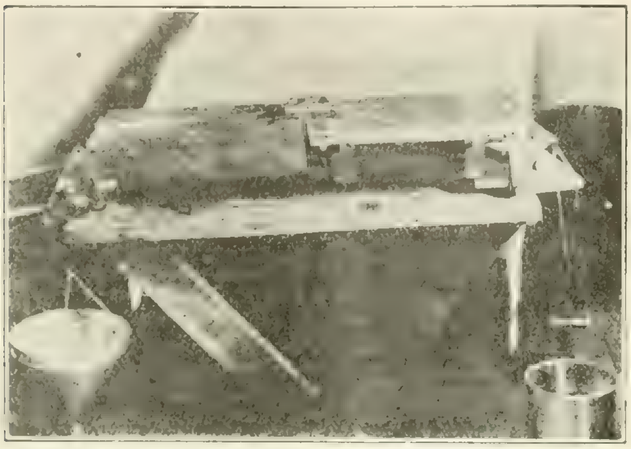


Fig. 1—Tension and Shearing Platform.

The possibility of water reaching the soil beneath a foundation should receive careful consideration. Certain soils, such as sand and gravel, are not materially affected by saturation, but are readily eroded by flowing water. On the other hand, clay is not eroded by flowing water, but the surface is readily softened and, when so softened, is plastic and flows under pressure.

Subject to the above considerations, it is the opinion of the committee that, for the greater number of types of structures, the safe bearing value of soil should be limited to one-half the value, shown by a compression diagram, between the point where the soil is merely compacted and that where displacement begins. That value can be modified as needed, either way, depending on the character and importance of the structure proposed. Such a value agrees fairly well with common practice and usual soil conditions as they have been observed.

It should be noted that allowable load, as herein defined, may be regarded as a function of settlement, whereas bearing capacity may be regarded as the ultimate load the soil will bear without displacement, and displacement is the ultimate measure for settlement. With this in view, the committee proposes to submit to the membership a blank form on which to record observed settlements and loads, with the desire that such records be submitted to it for compilation.

Soil-Testing Apparatus.—The notes on the drawings submitted and published with the 1920 report on the use of the soil-testing apparatus appear to be fairly clear as far as dry soils are concerned. The discussions of the committee seem to indicate, however, that certain phases of the case should be further considered, such as that of wet ground. To use the apparatus proposed in wet ground at all, it would be necessary to unwater the soil, at least until the time the apparatus was in place, because it is presupposed that the soil beneath the bearing-plate is dressed to a fairly smooth contact with the bearing-plate. This could not be done under water, particularly if the soil contained stones or gravel. A test on soil, however, should represent the value of that soil under its actual working conditions, and if the soil is unwatered for the purpose of placing the apparatus, the water should be allowed to return before making the test.

If the test is made on wet soil without special precautions, using the apparatus described, it is believed that there would be a squeezing out of the soil between the edges of the bearing-plate and the tile which surrounds it. It is suggested that this might be overcome in a manner similar to that used in a press for fruit pulp by spreading a strip of burlap, or other similar material—which would permit the water to pass through and retain the grains of the soil—over the surface before placing the bearing-plate, tile, and back-filling. It is not believed that the burlap would have any appreciable effect on the recorded bearing value of the soil.

Under the conditions described, however, there would be a possibility of the surrounding soil rising from the pressure exerted by the compression plate. The recording gauge attached to the side of the pit, or the compression post itself, therefore, should be referenced in some manner to the elevation of a point beyond the zone of influence. This might be conveniently done with an engineer's level.

The committee has developed a small type of soil compression apparatus based on the principle of penetration. The instrument has had considerable use and is believed to give consistent results. It is comparable in its action to the larger type of field-testing apparatus submitted in the 1920 report of the committee, and is designed to give the amount of penetration for a given pressure on 1 sq. in. (in circular form) in any given length of time, the larger type of apparatus having been designed to test an area of 1 sq. ft.

In this connection attention should be called to the fact that all such tests are relative only, the penetration not varying inversely with the area on account of the pyramiding effect of soil stresses in compression. This is equally true of foundations in general. In the case of both the large and small compression machines, bearing-plates of varying areas may be used to suit soil conditions.

Laboratory Apparatus.—The committee has not heretofore entered into the question of laboratory equipment. A considerable amount of work, however, has been done for the purpose of grading soils and soil materials. The equipment may be divided into the following class:

1.—Centrifugal separator (not now in use).
2.—Centrifugal elutriator (not now in use).
3.—Centrifugal compactor.
4.—Tension and shearing apparatus.
5.—Sample washing machine.
6.—Centrifugal screening apparatus.
7.—Schultze elutriator.
8.—High-speed centrifuge.
9.—Rotating color disks.

The centrifugal compactor was developed in order to obtain uniform density in the packing of samples of granular material to be used in tests.

Fig. 1 illustrates the apparatus finally developed for making tension and shearing tests of soil samples under varying degrees of compaction. Considerable time and thought was expended on the method to be adopted for sampling soils, various types of equipment and containers being devised. However, the committee finally came to the conclusion that the simple method of using a sharpened shell to dig into the soil to remove it, was the most satisfactory solution for small samples. For more accurate and reliable tests, however, it is desirable to take as large a volume as possible. For instance, a unit of 10 to 20 cu. ft. should be removed, and the weight, porosity, water content, etc., determined.

There is one outstanding feature to which the committee would direct attention. In the development of screening and separating methods the substitution of a standard centrifugal force for gravity facilitates and improves the processes. For example, the use of the high-speed centrifuge has made possible the precipitation of microscopic and ultra-microscopic particles. Through this means the value of colloid clay has been identified and its collection simplified.

The personnel of the committee is as follows: Robert A. Cummings, chairman; Walter J. Douglas, secretary; E. G. Haines, Allen Hazen, J. C. Meem.

Torsion on Rectangular Sections

Torsion on rectangular sections is the subject of an article by Prof. C. R. Young in the Canadian Engineer of March 24, 1921. A summary of the article follows:

Cases of torsion on rectangular sections are of frequent occurrence in practice, and under certain conditions the stresses resulting therefrom may be large. Wall beams, girders or headers next to floor openings and wall foundation beams used in cantilever wall footing construction are examples of members subjected to twisting or torsional moment. The existence of stresses due to such moment has been recognized, of course, but only rarely are any rational efforts made to proportion members for them.

Such analyses of the stresses produced by torsion as are commonly made in the hurry of practical work are generally made on the assumption that the theory pertaining to torsion on circular sections applies also to rectangular sections.

The ordinary theory of torsion is based on the assumptions that no normal stress (tension or compression) parallel to the axis of the prism twisted accompanies the torsion. This assumption agrees with observations made upon specimens with circular cross-section, which show no distortion of circumferential lines drawn upon them prior to torsion. This cannot be said of any other form of cross-section, however, where distorting effects are very evident. The common theory is, however, based upon the former or simplest type of section, for which all right sections remain plane during the twisting.

Another assumption of the common theory is that both the positional displacement, or slide, of points on a right section and the torsional shearing stress increase uniformly with the distance of the point considered from a central point at which both deformation and stress are zero; that is, from the centroid of the section.

These assumptions do not apply to sections other than circular. In such sections normal stresses (that is parallel to the axis of the prism) are set up. The sections become warped; right sections do not remain plane after torsion.

Recognizing this St. Venant developed his theory of torsion for prisms with non-circular sections upon different assumptions. While for a square section the true maximum torsional shearing stress is only 6 per cent greater than is given by applying the common or circular-section theory, for a rectangle with the long side twice as great as the short one, the true maximum stress is 50 per cent greater than is given by the common theory.

Circular-Section Theory.—Saint-Venant was able to base his analysis upon (1) facts of experiment established by Savart, reported in 1829; (2) upon certain torsion tests made by Duleau, in 1820, on bars of square and circular cross-section of the same material and the same moment of inertia; and (3) upon special tests by Saint-Venant himself made on two prisms of rubber. Straight lines were traced transversely on their lateral faces before the experiments, and on the application of torsion it was found that these lines became curved in S-shape, their ends remaining normal to the edges. This showed conclusively that the cross-sections of rectangular prisms did not remain plane sections under torsion, and indicated that at the corners the shearing stresses were zero.

In 1853 Saint-Venant brought forth his general formula for the solution of torsion in prisms with non circular sections. This formula is cumbersome, containing 8 independent variables and hyperbolic functions.

Perhaps the most remarkable conclusion reached by Saint-Venant in his investigation of rectangular sections, was that the maximum torsional shearing stress does not arise at the corners of the rectangle, as was implied in the common or older theory, but at the centers of the long sides. Along the short sides, the stress also attains a maximum at the centers, but this maximum is less than that developed at the centers of the long sides. As indicated in Fig. 1, the stress increases uniformly along the median lines from zero at the centroid to a local maximum at the center of each side. Along diagonals, however, this shearing stress increases from zero at the centroid to a maximum at some point intermediate between it and the corner, while at the corners the stress is zero. Along any side the stress varies approximately as the ordinates to a parabola, shown in Fig. 1, with zero stress at the corners and the maxima at the centers of the sides.

Subsequent tests made by Burr [illegible], and others, proved the correctness of Saint-Venant's theory. Rectangular bars have been marked off with a series of longitudinal and transverse lines, exactly at right angles to each other, and then the bars have been subjected to torsion. The bars after twisting showed a distortion of the rectangles into rhombuses, the greatest distortion of the right angles being at the middle of the long sides, while the transverse lines remain as near as can be observed perpendicular to the edge lines of the bar. Since stresses are proportional to distortions, it is reasonable, therefore, to assume that the shearing stress at the middle of the long sides is greater than that at the middle of the short sides, and that there are no shearing stresses at the corners. This view is further substantiated by the fact that if the bar be twisted to failure, rupture usually begins at the middle of the long sides.

Approximate Torsional Strength.—For most purposes of design and investigation, the exact formulas derived by Saint-Venant may be replaced by approximations thereto without material error. Thus, Saint-Venant gave, in footnotes to his memoir, empirical formulas which give results differing by less than 4 per cent from the correct theoretical values. If q_1 be the maximum shearing stress (at the center of the long sides), then, according to Saint-Venant, the torsional moment, or torque, that must be applied to the specimen to produce this stress may be stated as

$$T = b^2h^2q_1/(1.8b + 3h) \quad \ldots\ldots (1)$$

This formula is given in Johnson's Materials of Construction, as a suitable approximate one for application to rectangular sections.

In Merriman's Mechanics of Materials, and Mark's Mechanical Engineers' Handbook, the formula presented is somewhat simpler. It is

$$T = 2/9\,b^2hq_1 \quad \ldots\ldots (2)$$

Woods, in his Strength and Elasticity of Structural Members, gives a similar formula, the only difference being that the coefficient 2/9 is replaced by a variable coefficient. His formula is

$$T = \kappa b^2hq_1 \quad \ldots\ldots (3)$$

where k has values varying with the ratio of h to b as follows:

h/b	k.	h/b	k.
1	0.208	3.5	0.275
1.5	0.231	4	0.282
2	0.246	5	0.292
2.5	0.258	10	0.312
3	0.267		

In his Resistance of Materials, Slocum presents a somewhat lengthier expression for the torque, namely:

$$T = bh(b^2 - h^2)^{1/2}q_1 \div (4.08 + 2.7h/b) \quad \ldots\ldots (4)$$

Comparison of Approximate Formulas.—The torsional moments, as computed by formulas (1), (2), (3) and (4), required to produce a given maximum shearing stress are found to differ considerably. A comparison of the results obtained from each of these with the results arrived at by applying Saint-Venant's exact formula for rectangles having side ratios, h/b, = 1, 2 and 3, is of interest. Taking the torque T found by the exact formula for each rectangle as unity, the results from the five formulas would be as given in Table I.

It appears from this comparison that the Woods' formula (3) gives correct results if the variable coefficients listed with it are used. The approximate formula proposed by Saint-Venant himself is accurate for the square, but is 4 per cent in error for the rectangles having side ratios of 2 and 3. The Merriman formula is least accurate of all, being 17 per cent in error for the rectangles with

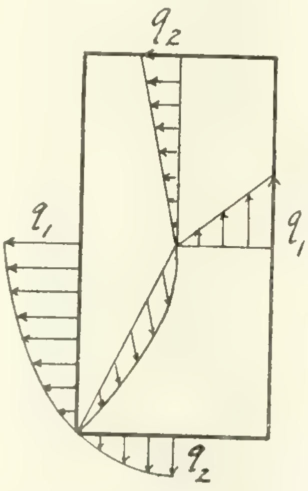


Fig. 1.

TABLE I. COMPARISON OF TORQUES COMPUTED BY VARIOUS FORMULAE FOR RECTANGULAR SECTIONS.

Authority and formula No.	h = b.	h = 2b.	h = 3b.
C. R. Young's adaptation of Saint-Venant exact formula	1.00	1.00	1.00
Saint-Venant, approximate (1)	1.00	1.04	1.04
Merriman (2)	1.07	0.90	0.83
Woods (3)	1.00	1.00	1.00
Slocum (4)	1.00	0.96	0.97

a side ratio of 3, and still more for rectangles with greater side ratios. For all practical purposes, therefore, the Woods' formula (1) may be used with confidence.

Torsion on Reinforced Concrete Beams.—So far, the discussion has been confined to homogeneous and isotropic beams; that is, to those that are composed of material of uniform composition and of the same resisting and elastic properties in all parts, and in all directions. Well-made, plain concrete may properly be assumed as such a material, but concrete containing reinforcement cannot be said to be either homogeneous or isotropic. A consideration of the observed effects of torsion on rectangular prisms of isotropic material will, however, afford some guide to the proper disposition of reinforcing material to resist torsional stresses.

It is well known that the edges of a rectangular bar subjected to torsion assume a spiral form, and that high tensile stresses are set up along the edges parallel to the axis of the piece, if the angle of twist be great. This is evident from the fact that the elongation of the edges of a ductile specimen twisted to destruction may be as much as 20 or 25 per cent, due to the formation of helices. The cracks that open out across these edges arise from the stressing of the material beyond its ultimate strength in tension.

Such longitudinal tensile action being set up in a rectangular piece, it would appear that longitudinal reinforcement in the corners of a concrete beam subject to torsion would be useful. Steel so disposed as to resist the deformations incident to torsion in the most effective manner, is obviously employed to advantage. These corner rods carried for the full length of the beam and adequately embedded or anchored would reinforce the cross-section against warping.

Torsional Shear Reinforcement.—Provision for torsional shearing stresses on a given cross-section should be made in very much the same way as it is made for ordinary shearing or diagonal tensional stresses. The inferior strength of concrete in tension as compared with shear naturally tends to bring about rupture of a torsion specimen of concrete along diagonal lines, and this is substantiated by actual experiment. Mörsch reports torsion tests on several concrete cylinders at Stuttgart, in which rupture occurred along a spiral surface inclined at 45 degrees with the axis.

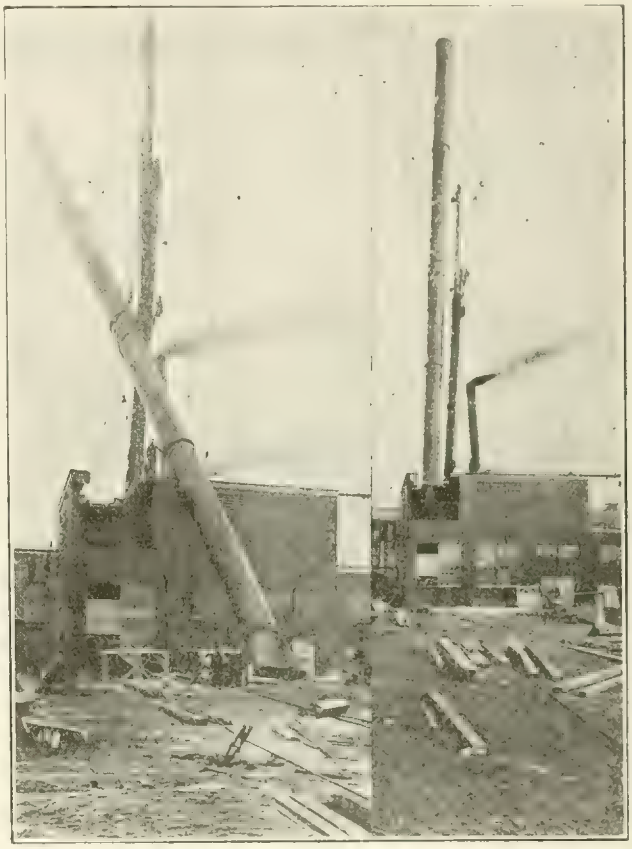
Inclined stirrups or bent-up rods in beams placed there for the purpose of resisting vertical shear, or diagonal tension, have some value, so far as they go, in resisting torsion. For torsional shear, however, they should run in opposite directions on opposite faces of the beam. On one side next the loading, the usual bent up steel is available for the resistance of both vertical shear and torsion, but on the other side it runs in the wrong direction to resist torsional stresses. However, as the existing vertical shearing stresses operate against the torsional stresses, the steel on this side may not be required at all for torsional stresses. Some designers have, for beams carrying a heavy torsional moment, placed all the inclined steel on the side of the beam, where the vertical shearing and torsional shearing stresses are combined. Such practice assumes that on the other side, the two kinds of shearing stress offset each other to such an extent that the net shearing stress is within the capacity of plain concrete.

For very heavy torsional stresses, additional reinforcement may be provided by placing steel in the top and bottom faces inclined to the axis of the beam at, say 45 degrees. In such cases, the natural system of reinforcement to employ would be heavy wires, or light rods wrapped about the longitudinal steel as a 45-degree spiral with a pitch such that at least one inclined rod would be cut on each face of the beam.

Herbert Hoover Resigns as President of American Engineering Council.—Herbert Hoover has resigned as president of American Engineering Council of the Federated American Engineering Societies. His resignation was submitted and accepted as the closing action of the sessions of the council held April 16 at the Engineers' Club of Philadelphia. Mr. Hoover gave as his reasons the fact that American Engineering Council by its constitution was necessarily engaged in furthering national activities which involve legislation; and that he as a member of the executive branch of the Government could not consistently direct such activity as an officer of American Engineering Council. The council, in a resolution of regret at Mr. Hoover's retirement, voted its appreciation of Mr. Hoover's leadership during the organization period of the council and his initiation of policies and effort

130 Ft. Steel Stack Erected in One Section

An interesting piece of erection work has just been completed at the West Milwaukee, Wis., plant of the Chain Belt Co., where extensive plant additions have been going on for the past two years. To take care of the heating of the new buildings a new 400-HP. B. & W. watertube boiler was added to the existing heating plant in connection with which a steel stack 130 ft. high by 4½ ft. diameter was erected. This stack built in the shops of the company when placed on top of the boiler was 154 ft. from the ground to the top and was erected complete in one section. It is stated to be the largest stack to be erected in this manner in the Milwaukee district. The stack weighed about 12 tons and to accomplish the erection it was necessary to place a 15 in. x 75-ft. pole on top of the boiler with a triple reinforcement about two-thirds the height of the pole and held by means of eight steel guy ropes secured to the main columns of the surrounding buildings. The erection was handled in two stages, the first stage being to lift the stack from the ground to an inclined position with the top end resting on the boiler house, and then to a vertical position after which it was landed in place. By handling the erection in this manner, the cost was considerably less than if the stack had been made in two sections with a slip joint or built up in place by means of a scaffold.



Erecting a 130-Ft. Steel Stack in One Section.

Split Posts and Round Posts.—Is a split fence post as durable as a round fence post? This is a question frequently asked of the U. S. Forest Products Laboratory. The fact is, one kind of post will last about as long as the other if the amount of heartwood is the same in both. But if the percentage of sapwood is increased by splitting, the split post will be less durable, and if the percentage of heartwood is increased, it will be more durable than a round one. Posts of spruce, hemlock, or any of the true firs are exceptions to this rule, because their heartwood and sapwood are about equally durable. When posts are to be treated with creosote or other preservative, a round post is preferable to a split post, because of the comparative ease with which the sapwood can be treated. The heart faces on split posts do not, as a rule, absorb preservative well. Split red-oak posts will take treatment, because the wood is very porous, but the heart faces of split posts of many other species, notably white oak, red gum, and Douglas fir, resist the penetration of preservative, even under heavy pressures.

Importance of Site Planning in Industrial Housing*

By MAURICE R. SCHARFF,
Assistant Chief Engineer, Morris Knowles, Inc., Pittsburgh, Pa.

In spite of the temporary relief from house shortage experienced by a few industrial centers as a result of the wave of depression now passing, the housing problem is still unsolved. In the large majority of cities, the shortage of homes is more acute than ever, and common sense tells us that it must remain acute until the accumulated deficit in house building over these past five years has been made up somehow.

Housing—A Nearly Insoluble Problem.—Nor will this deficit be made up for a number of years to come. There has been much loose talk about housing during the past two years, and scarcely a city can be found that has not had its share of committees, community housing projects, etc. It is only recently that we have come to realize that the problem, under present conditions, is practically insoluble by the ordinary economic processes.

Thanks to the inequality of distribution of the influence of our unstable monetary unit, building costs have been maintained at a level where a reasonable proportion of the incomes of the great bulk of the population would no longer pay a rental sufficient to permit even a moderate return upon capital invested in new houses. And the instability of the situation has made impossible any assurance of the continuance, even of such return as could be earned, for a reasonable period of years.

A Suggested Economic Remedy.—No business in which return on capital constitutes so large a proportion of the total revenue required as in the case of housing, could survive this economic impasse. It can be confidently predicted, therefore, that all efforts to stimulate the industry by conferences, congresses, hearings, discussions, community organizations, etc., are doomed to failure until wages, salaries, prices and rentals return to a reasonable relation with one another, with promise of reasonable stability, or unless home building is subsidized. And this situation will recur with every future period of excessive inflation and price increase, until some method has been found to eliminate the present inequality of distribution of the effects of price fluctuation—the most hopeful proposal for which seems to the writer to be the plan to stabilize the currency by the adoption of a dollar of variable gold exchange value and constant purchasing power, in place of our present dollar of constant gold exchange value and variable purchasing power.

Subsidies and Inducements.—Such relief, however, is for the more or less distant future. At present the only alternative to a policy of "watchful waiting," bearing, meanwhile, as best we may, the evils of the present house shortage, is subsidy. Housing may be subsidized in a number of different ways, among which may be mentioned the following:

1. Actual construction and rental or sale of houses at less than cost by national, state or municipal governments.
2. Loan of capital for housing at less than market rate of interest, by national, state or municipal governments. (Home loan banks, etc.).
3. Exemption from taxation of new houses, mortgages, etc.
4. Subsidy as in (1) or (2) by civic organizations, community housing companies, etc.
5. Subsidy as in (1) or (2) by industries for housing employes.

Our experiences with government management during the war have made the first method referred to above especially objectionable to the people of the United States, and no one would seriously propose it today. The demand for "less government in business" is opposed to the second method; and the serious evils resulting from existing tax exemptions do not encourage further experiments in the direction of the third method; although possibly the urgency of the situation may yet compel us to run the risk of trying out one or both of these last two plans.

An Industrial Opportunity and Obligation.—Experience has shown that no substantial amount of capital can be obtained by the fourth method. But none of the objections, pointed out above, apply to industrial housing, subsidized by the industry, and a great contribution to the solution of our present difficulties can be made if our industrial leaders will fulfill their obligations in this respect to the communities in which their plants are located.

For, as Mr. Morton H. Tuttle puts it, "An undigested industry is not an asset; it is a liability." As long as the present situation persists, it is the duty of industries to assist in the housing of the employes they have attracted into the community, and the splendid way in which many industrial companies have performed this duty furnishes an example and an inspiration to the rest of the industrial world.

However, it is not necessary to appeal to a sense of civic duty for arguments in favor of industrial housing. Nor does a subsidy to such housing constitute paternalism or philanthropy. For no portion of the overhead expense contributes more directly toward efficient and profitable production; no item of investment earns larger returns in contentment and loyalty than does a good industrial housing development.

The Importance of Site Planning.—If, then, industrial housing is desirable, from the point of view both of the community and of the industry, the importance of site planning in such developments will be apparent. For housing does not consist of houses alone. These are important, but houses must be located in groups, and no matter how well they may be designed to furnish shelter and comfort within the house, they will utterly fail to fulfill their purpose unless their arrangement and their environment, including the ways for passing to and from them, and to and from the working places of their occupants, together with all the multiplicity of services which are required for the health, safety, convenience and amenity of modern city dwellers, are equally well planned.

An industrial employe who works 8 hours per day, 300 days per year, spends about 27 per cent of his time in the plant, and about 73 per cent outside of it. But the workman is affected as much or more by the influences to which his family is subjected, as by those acting directly upon himself. And if an average family be taken as five, with 1½ workers per family, then the actual proportion of the family's time spent in the plant is only about 8 per cent, while 92 per cent is spent under the influences of the home and the community.

If this method can be used (as seems reasonable to the writer) to measure the relative importance of conditions in the plant and in the community in affecting the health, happiness, contentment and efficiency of the workman, then a similar method of reasoning would give to the planning of the site an importance fully equal to that of the planning of the house, and perhaps greater. And this is a better measure than the relative costs, which were estimated for a typical, average development, in a study made some months ago by Mr. Morris Knowles with the collaboration of the writer (and published in Mr. Knowles' book on "Industrial Housing") at about 75 per cent for the houses and 25 per cent for the land and improvements.

The Results of Site Planning.—The objects to be aimed at in site planning for industrial housing, and the results which may be accomplished if such planning is wisely done, may be summarized as follows:

1. Selection of a site conveniently located with reference to the industry, and the needs of the workers.
2. Proper provision for direct and easy means for traffic communication, within the community, between the community and the plant, and between the community and its environment.
3. Arrangement so as to derive the greatest possible advantage, both from existing natural conditions, such as topography, soil and prevailing winds, and from the artificial environment, including highways, railroads and adjoining communities.
4. Proper provision for the conservation and preservation of the health, safety and welfare of the workers and their families, and for the stabilization of property uses and values.
5. Proper provision for all utility services, for facilities for commerce and business, and for public and semi-public buildings and activities.
6. Capacity for ready extension to meet future needs, as well as adequacy for present requirements.
7. Attractiveness.

Planning Lowers Cost.—While the greatest economic value does not always mean the lowest first cost, nevertheless a good layout, meeting the above specifications, will generally be lower in first cost of streets, utilities, lot grading and house foundations than the usual stereotyped layout. For instance, in the ordinary grid-ironed street plan, with alleys and with the proportion of street area, commonly found in such layouts, the total area of land available for building purposes rarely exceeds 50 per cent. On the other hand, a good design, with rational street system and street widths, generally yields from 65 to 78 per cent of land available for buildings. These figures are derived from a number of examples actually built.

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*A paper read at the recent convention of the Indiana Sanitary and Water Supply Association.

A Striking Comparison.—The case for the well designed layout is particularly strong, where the land to be developed is hilly.

Mr. A. G. Dalzell of Vancouver, B. C., has made an interesting comparison of two layouts of somewhat similar area, but illustrating these two different types of planning. In one tract the streets were laid out with due regard to the topography, the streets curving at easy grades with the contour of the land; in the other, the usual rectangular system was used. Both tracts were situated on similar topography, within about an equal distance from the center of the city.

The contour layout had a total area of 400 acres, of which 269 acres were used for building and about 6 acres for parks. The rectangular layout covered an area of 415 acres, of which 252½ acres are available for building area, with only 2.4 acres devoted to parks. On the basis of the same unit prices, and with careful corrections made for unusual items of construction, the total costs of streets and utilities alone were, respectively, in the contour layout, $760,000; and in the rectangular layout, $1,500,000. In other words, by virtue of reduced grading and utility costs, and lesser area used for streets, the cost for public improvements in the "good" layout was only about half that of the rectangular layout. Clearly, here the "good" layout has a distinct economic value.

Some First Principles.—A good layout accomplishes more convenient and quicker means of communication and transfer of traffic, and therefore makes for more efficient commerce and business. While a good lyout may include many straight streets, and may even use rectangular blocks to a large extent, it will always provide the most direct route possible from end to the main objectives, by the use of main thoroughfares with the lowest gradients that can be obtained. The saving in time by traveling on the hypothenuse of a right triangle, instead of the two sides, amounts to about 20 per cent for each trip, or to 12 minutes out of each hour. By avoiding difficult gradients on main thoroughfares, the saving in time may be much greater.

A good layout will conserve and promote the health, safety and welfare of the inhabitants of the community by providing plenty of light and air, proper provision for utilities, land for parks and recreational facilities, civic and semi-public buildings and will, without undue expense, render all of these features reasonably attractive.

Zoning Helps Tracts as Well as Cities.—Proper site planning will also include zoning, which is just as important in a housing development as in a complete city. The determination in advance of the uses to which land shall be put, instead of its uncontrolled development by short-sighted greed for gain, will conserve property values, render operation and management easier, and avoid many serious social problems.

Wise site planning, however, will not be confined to consideration of conditions within the housing development alone. Where the project is part of a larger community, its relation to the latter and the joint solution of their planning problems become of the highest importance. Indiana is to be congratulated upon the present prospect for making such joint solutions easier, in the carefully drawn city planning and zoning legislations now pending in the Indiana legislature. When these bills have become laws, and when city planning commissions have been established in accordance with their provisions, the industries of the state may then undertake to make their proper contribution to the housing facilities of the communities in which they are located with confidence that the values which they create will be maintained and that their own developments will be properly co-ordinated with a comprehensive plan for the development of the entire community. If they then give to the planning of their housing layouts the attention which its importance justifies, the full benefit of industrial housing, both to the industry, the [illegible] will [illegible]

The Design of a Tree

"How do you suppose they stand that high without proper wind bracing?" Mr. R. Fleming of the American Bridge Co. once received a picture postcard of a long leaf Southern pine on which an engineer friend had written that question; and in "Engineering Education," the Bulletin of the Society for the Promotion of Engineering Education, he tells of the incident and the following answer, which he found in Woodward's "Rational and Applied Mechanics."

A Cantilever of Uniform Strength.—Nature builds cantilevers of "uniform strength" in the shape of tapering trunks of trees, which are solid, and in bamboo poles and wheat straws which are hollow. The wind blows from any horizontal direction, so the cross-sections are circles or rings, of varying radii. If, like a palm or a tall southern pine, the load is concentrated (that is, if the foliage which catches the wind is bunched) at the top, it is a cantilever with a load at the end. If W is the total force of the wind (in pounds) and h the distance from the ground to the center of wind pressure, the bending at any height is $M = W (h - z)$. The value of I for a radius x is $I_x = \pi x^4/4$ and a is p_1/x. Hence

$$M = aI = \frac{p_1 \pi x^3}{4} = W(h - z)$$

and

$$x^3 = \frac{4W(h - z)}{\pi p_1},$$

which is the equation of a cubic parabola with the vertex at the top of the tree

Hence the effective radius at the base is $R = \sqrt[3]{4Wh/p_1\pi}$ in which p_1 is the fiber stress just under the bark, on the assumption that the internal stress varies unifromly (that is, that E is constant for all radii). So much for the ideal tree. Actual measurements show a fair approximation on the part of real trees to the ideal form of a cubic-paraboloid of revolution.

If the tree stands alone on the level plane, it is more often shrouded with a foliage nearly to the ground, so that it approximates a cantilever with a uniform load, and the trunk tapers more rapidly, in accord with theory, which is, that it approaches a common parabola in outline.

$$x^2 = \sqrt{\frac{2W}{\pi f}(h - z)}.$$

In the case of a growing bamboo, we see an economic cantilever of "uniform strength" in the shape of a conoidal tube.

Text Books, Professors and Engineers

"From the Notebook of an Engineer" is the title given by Mr. R. Fleming to some reflections from which we quoted in the preceding article, and from which we now quote again. These were published in the Bulletin of the Society for the Promotion of Engineering Education.

Texts for Students and Texts for Practitioners.—A textbook while adapted to the classroom may be disappointing as a book of reference. One professor says that a book cannot be written that will be equally valuable to a student and a practicing engineer. He is somewhat mistaken. A textbook should contain more than is actually taught in the college course. The student should not be led to think that he has exhausted a subject when he has finished the textbook. It goes without saying that the books a student uses in college are those that he will turn to in after years for help in time of need. As Professor DuBois wrote 40 years ago: "It is surely, then, no objection that such books should give a complete view of the whole ground, rather than a short and meager presentation, which can have but a transitory value in merely introducing the student to the subject, and which often lead him to suppose that there is but little more of it worth knowing." Some excellent American textbooks could profitably be made longer. The distinctive material for the college course could in some way be indicated.

The Pro and Con of Problems.—A great asset to a textbook is plenty of numerical examples, especially if they are problems such as an engineer meets in professional life. Many of the later textbooks, more particularly those in Mechanics and Strength of Materials, are giving such problems in abundance. Morley says in the Preface of his book previously noted: "Many fully worked out numerical examples have been given, and the reader is advised to read all of these, and to work out for himself the examples given at the ends of the chapters, as being a great help to obtaining a sound and useful knowledge of the subject."

Contrary to Morley's practice and views are those of Woodward as given in the Preface of his book previously noted: "The author has not cared to multiply problems. To go beyond clear illustrations of genral principles and useful methods of analysis, is to waste time and opportunity. To ring endless changes upon bodies falling in a vacuum, and projectiles flying through empty space, is to kill time and 'keep students busy.'" It is not necessary for the student to work out all the problems of a large collection. Merely reading them is educational. Having the answer to a problem, given either after the problem or in the appendix, is a great help to the student outside of college walls. It is doubtful if much is gained by withholding answers from college students. The writer was told by a professor that in his institution solutions to the problems in the textbooks used could be found in the various fraternity houses, being handed down from one generation of students to another.

Nothing detracts from the working value of a book so much as errors, typographical and otherwise. An example may have the decimal point in the answer misplaced, an equation may have the × sign where the + sign is intended or there may be downright errors in the text itself.

Did It Ever Happen to You?"—"I like to have errors in the textbook," said one professor. I come before the class and this colloquy ensues:

"'Gentlemen, have you gone carefully over the lesson?'

"Silence gives consent.

"'Did any of you have any trouble with it??'

"Usually another silence.

"'Well, did you all verify Equation (blank)?'"

Equation (blank) is an error, and the professor has them trapped. This may be fine for a class; it encourages thought and shatters a belief in the infallibiilty of textbooks. But the practicing engineer seldom has time to verify equations. He wants to take them as they are written. However, this is with some books an unsafe practice, especially with the first edition.

A clearing house for information regarding technical articles written by professors and published in the periodicals of their respective colleges is a thing to be desired. A professor often gives time and thought to elaborating a subject in which he is particularly interested and presents the results of his studies in the college periodical.

How Napier Invented Logarithms

We quote a third time from Mr. R. Fleming's Note Book, which furnished the material for the two preceding articles.

The writer has searched fully a hundred textbooks for certain information regarding "Napierian," "natural" or "hyperbolic" logarithms. How they differ from the common logarithms, how one system can be changed to the other, how they are determined, are all explained. But just what did Napier discover or invent? How did he derive his logarithms? Whether "higher arithmetic," "university algebra" on advanced calculus were examined—they all failed to give Napier's line of thought or his methods. (It should be remembered that Napier gave his wonderful invention to the world in 1614—before Sir Isaac Newton was born and 60 or 70 years before the birth of the calculus.) It was only when the writer came across Cajori's "History of Elementary Mathematics" that his queries were answered. The information contained in the sentences quoted from this excellent book will be new to many readers:

"His logarithms were the result of prolonged, unassisted and isolated speculation. . . . In the time of Napier our exponential system was not yet in vogue. . . . That logarithms flow naturally from the exponential system was not discovered until much later by Euler. . . . Napier calculated the logarithms, not of successive integral numbers, from 1 upwards, but of sines. His aim was to simplify trigonometric calculations. . . . It is evident from what has been said that the logarithms of Napier are not the same as the natural logarithms to the base $e = 2.718$. This difference must be emphasized, because it is not uncommon for textbooks on algebra to state that the natural logarithms were invented by Napier. . . . It must be remembered that Napier did not determine the base to his system of logarithms. The notion of a 'base,' in fact never suggested itself to him. The one demanded by his reasoning is the reciprocal of that of the natural system." Further along in the same book we read, "In the study of quadratures Gregory St. Vincent found the grand property of the equilateral hyperbola which connected the hyperbolic space between the asymptotes with the natural logarithms, and led to these logarithms being called 'hyperbolic.'"

Regarding the nomenclature, Napierian or natural, it may be interesting to note that Webster's International Dictionary under "logarthm" mentions Napierian logarithms, "which are often confounded with natural logarithms with which they are connected by the relation.

$$\text{Nap. log. } n = 10^7 \left\{ \text{nat. log.} \left(\frac{10^7}{n} \right) \right\}\text{"}$$

On the other hand, the Standard Dictionary states, "Napierian or natural logarithms have for a base 2.718281828." In Vol. VI (1850-1854, page 397) of the Proceedings of the Royal Society of London the "Base of Napier's Logarithms" is carried to 205 places of decimals.

Napier's line of thought is expressed in the International Encyclopædia: "Napier observed that if in a circle, with the radius OA_o, OA_1 $(r = 1)$ at right angles, the sine S_oS_1, parallel to OA_1 moves from O to A_o at intervals forming an arithmetical progression, its value decreases in a geometrical progression. The segment OS_o Napier originally called numerus artificalis, and later logarithmus (ratio numbers)."

For a full presentation of Napier's line of thought and deductions therefrom the reader is referred to the articles by Professor Cajori in the American Mathematical Monthly, Vol. 20, 1913; "John Napier and the Invention of Logarithms," Professor Hobson and the "Napier Tercentennary Memorial Volume." See also the valuable articles, "Logarithm" and "Napier" in Encyclopædia Brittanica, Eleventh Edition.

Napier published his book, "Mirifici logarithmorum canonis descriptio" in 1614. In it he explained the nature of his logarithms and gave a logarithmic table of the natural sines of a quadrant from minute to minute.

A copy of the 1620 edition of this rare work is owned by the Public Library of New York City.

Stresses in Laminated Wood Construction

The use of heavy and light material of the same species in laminated or glued-up wood construction has less injurious effect than has been generally supposed. Laminated wood specimens under observation at the Forest Products Laboratory show little weakening or tendency to warp from this cause. Most warping and checking in laminated construction can be traced to one of two causes. The first is the use of plain-sawed and quarter-sawed lumber in the same construction, and the second is the combination of material of different moisture content.

Plain-sawed lumber of any species shrinks and swells more than quarter sawed lumber; and when the two kinds are glued together, they pull against each other with every change in moisture content. If the block containing such a combination is kept for a long time in the same atmospheric condition, the stresses die out, because the block checks or changes shape more or less to relieve the stretched condition of its fibers. As soon as the atmospheric conditions change, new stresses will be set up.

If boards of different moisture contents are glued together, internal stresses will result from the unequal shrinkage of the boards as their moisture contents equalize through seasoning. In some blocks made at the laboratory these stresses were large enough to rupture the wood. If the wood is not ruptured, the stresses will disappear permanently in time, but the block will have changed its shape somewhat in getting rid of them.

From these facts it becomes apparent that for laminated-wood articles where strength and accurate shape are required, it is desirable to use all plain-sawed or all quarter-sawed material, to have all pieces at a uniform moisture content when glued, and to prevent as far as possible subquent moisture changes by means of moisture-resistant coatings. For the manufacture of rougher articles where slight changes in form are of no consequence, these precautions are of much less importance.

Systematic Classification of Old Bridges

The system of investigation of old bridges by the Chicago, Milwaukee & St. Paul R. R. was discussed by Mr. C. F. Loweth, chief engineer, in a paper presented to the Western Society of Engineers on March 17, 1921. An abstract of the paper follows.

As standard for the investigation Cooper's Class E loading is adopted. In order to get the capacity of the bridge for the various locomotives and train loadings it is necessary to reduce also those loads to Cooper's Class E. After all engines and car loadings are classified according to the standard adopted it is a matter of direct comparison to tell whether a certain loading can safely pass over the various bridges.

The unit stresses which served as the basis for investigating the capacity of the various bridges were usually higher than those used in designing. The maximum unit stress permissible in old structures cannot be decided arbitrarily. Responsibility is placed on the engineer for the determination of the unit stresses. In choosing them the following has to be considered:

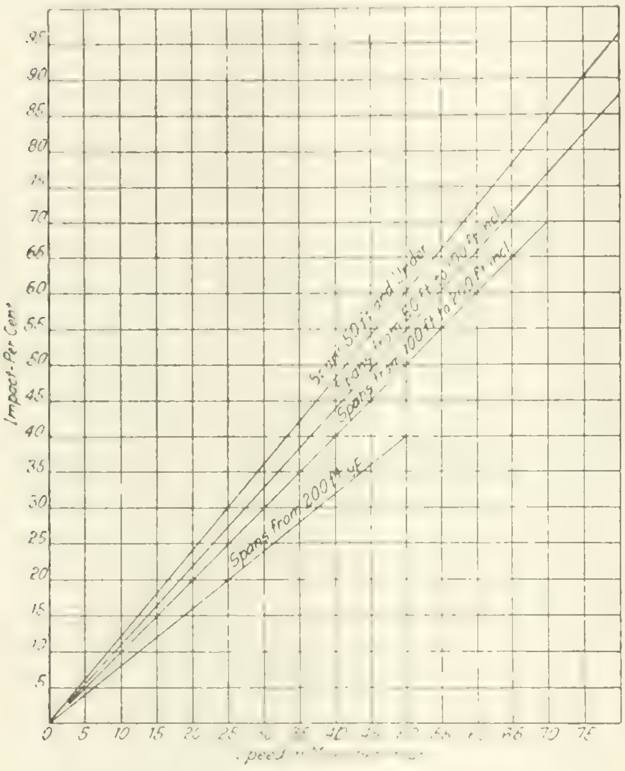

Fig. 1—Impact for Various Speeds and Lengths of Spans.

Considerations in Determining Unit Stresses.—The design—whether the details are well proportioned and direct in action, the degree of ambiguity or uncertainty as to distribution of stresses and of secondary stresses.

The character of workmanship and material entering into the structure as indicated by the reputation of the shop at which the bridge was built and the thoroughness of the inspection as disclosed by inspection reports of material and shop manufacture.

Deterioration and wear.

Action under load, such as rigidity and freedom from excessive vibration.

The speeds likely to obtain over the structure and confidence as to the observance of such speed restrictions as may be imposed.

The certainty as to the assumed loading being the maximum to which the bridge will be subjected.

Importance of the traffic and the hardship which might result from temporary disablement of the structure.

The reliability of the data upon which the investigation of the structure is based.

In general the exercise of good judgment and experience based upon all of the factors surrounding the bridge, its location, service and condition.

Axial stresses in tention per square inch may generally be taken as follows:

	Wrought iron.	Steel.
In flanges, beams and girders	20,000 lb.	24,000 lb.
In truss members	18,000 lb.	22,000 lb.

Stresses of other kinds should generally be proportional to these, the same as in the design of new structures.

To the designer of new structures these unit stresses seem large; in the case of old bridges they frequently seem small, especially in the case of the structure subject within regular service to stresses of such intensity and at the same time indicating little or no evidence of distress.

There may be at times conditions which may require, and at the same time justify increasing the limiting axial tension stresses to a maximum of 22,000 lb. for wrought iron and 26,000 for steel. It does not seem wise, however, to permit these higher stresses except in the case of structures which are to be removed or strengthened at an early date, or where the traffic over them is relatively unimportant. But the higher the stresses used, the more care and discrimination necessary for intelligent and safe application.

There are some details of construction in which it appears that the limiting stresses might safely be increased at a larger ratio over the axial stresses heretofore indicated. This, for instance, is true of stresses on the flange rivets in plate girders, stringers and floor beams. The failure of a girder in the flange riveting could not take place before ample warning of distress would be evident in the way of loose rivets, in this case the riveting could be strengthened before further failure could occur. It is, however, very seldom that flange rivets shows signs of overstress, in fact, the writer does not recall a single instance where our bridge inspectors have reported loose flange rivets.

In rating old bridges as to their maximum capacity, the impact allowance should be based on the probable maximum speed obtained. The speed is frequently known, and it can be restricted arbitrarily or it may be restricted due to the conditions surrounding the location of the bridges or the character of the traffic. It is desirable, therefore, for the purpose of rating old bridges, to determine not the impact for maximum speeds, but for such restricted speeds as the structure may be subject to, either by reason of arbitrary ruling or speed limitations brought about by the location of the structure as to proximity of stations, ruling gradients, etc.

The impact per cent for various speeds and for spans of different lengths are shown in Fig. 1. This compact diagram has been evolved from several diagrams upon which have been platted the results of the impact tests made by the A. R. E. A., classified as to speed of train and length of structures. One of these diagrams, Fig. 2, shows the impact observed for various speeds on deck plate girders from 43 to 80 ft. in length. This diagram includes a total of 14 spans, all of which have open timber floors except three.

These diagrams indicate that for all practical purposes the impact is directly proportional to the speed. The similar diagrams for truss spans show a similar condition, and on the basis of this practical information, the curves in Fig. 1 were drawn to cover the probable maximum impact for various speeds and different span lengths represented by the curves.

Methods of Investigation.—In general, the investigation for any part of a bridge would be as follows:

1. The maximum allowable stress is determined which, in the simpler cases, is the cross sectional area of the member times the limiting unit stress allowed.

2. Deduct from this the stress due to "dead load" and "wind load." The remainder gives the allowable stress for the "live load" effect.

3. Divide this by the stress for unit "live load" (Class E-1), which gives the classification for allowed "live load," if at rest.

4. Divide this classification by the term which takes into account the extra effect of the "live load," due to impact and centrifugal force, the result being the classification of the allowed "live load" at full speed.

As an illustration of this general method, the example of the hip vertical member known as U1-L1 of a truss. Assume that this consists of two steel bars, 4 in. wide by 1 in. thick, giving 8 sq. in. of cross section. If we assume that in this case the circumstances warrant the limiting unit stress of 24,000 lb. per sq. in., the total allowed stress is 192,000 lb. Assume that the dead load stress is 17,000 lb. and that the wind load is so small that it may be neglected. The total allowed stress available for live load is then 192,000 lb. — 17,000 lb. = 175,000 lb. The live load stress in the member for Class "E1" loading as determined by the usual methods of computing stresses in bridges, is 1,890 lb. The total allowed live load classification, if at rest, is therefore,

$$\frac{175{,}000}{1{,}890} = \text{E } 92.1.$$

Impact if taken by the ordinary formula

$$\frac{300}{300 + L} = \frac{300}{300 + 50} = 0.865$$

of the live load. Considering the bridge on straight track, the centrifugal force stress is zero. Therefore, if LL represents the net live load at full speed

$$\text{LL} + 0.856\ \text{LL} = \text{E } 92.1$$

$$\text{LL} = \frac{\text{E } 92.1}{1.865} = \text{E } 52.2$$

which represents the "Classification" of the member at the assumed unit stress. That is: An engine with wheels spaced as in the Cooper loading having 55,200 lb. on the driving axles and the other axle loads in proportion, will produce the assumed stress of 24,000 lb. per sq. in. if taken in connection with the other forces which are assumed to be acting.

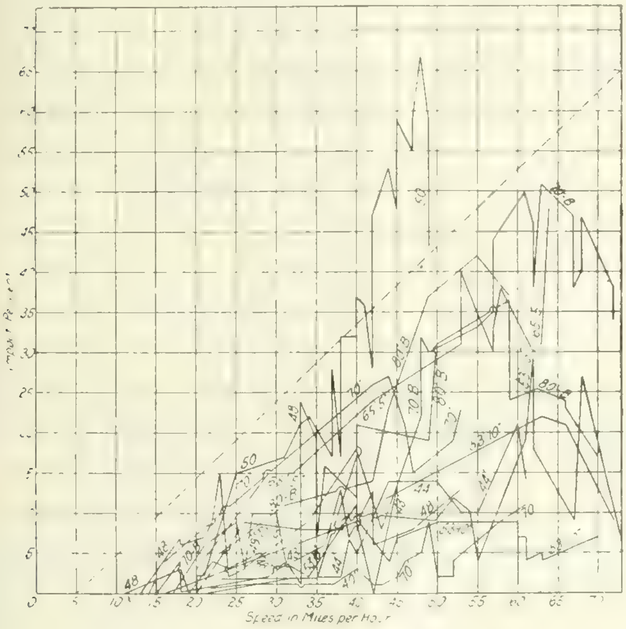

Fig. 2—Impact for Various Speeds on Deck Plate Girders.

It is surprising to observe the extent to which it is generally assumed that the effect of various train loadings on bridges is in direct proportion to the aggregate weight of the locomotives and cars. This, of course, is far from the truth and no approximation by such a method should be used to determine the safety of any bridge.

Figure 3 shows the classification of several types of United States Railroad Administration standard locomotives for various span lengths compared with the standard Cooper's Class E loading. The diagram shows for each of the locomotives the relation between the effect of the given engines on bridges as compared with the standard Cooper's loadings, which are used as a basis for the classification of bridges. The locomotives classified in Fig. 3 are listed in the following table:

LOADING CHARACTERISTICS OF 10 U. S. RAILROAD ADMINISTRATION LOCOMOTIVES.

Type.	Weight On driver axle.	Weight Total engine.	Weight Engine and tender.	Wheel base Driving.	Wheel base Engine.	Wheel base Engine and tender.
Pacific (4-6-2)...	55,000	270,000	414,000	13' 0"	34' 9"	67' 6½"
Pacific	60,000	300,000	444,000	14' 0"	36' 9"	70' 8½"
Mountain (4-8-2).	55,000	320,000	492,000	18' 3"	40' 0"	75' 8½"
Mountain	60,000	350,000	522,000	18' 3"	40' 0"	77' 8½"
Mikado (2-8-2)...	55,000	290,000	466,000	16' 9"	35' 1"	71' 5½"
Mikado	60,000	325,000	497,000	16' 9"	36' 1"	71' 9½"
Santa Fe (2-10-2)	55,000	360,000	532,000	21' 0"	40' 1"	76' 0½"
Santa Fe	60,000	390,000	596,000	22' 1"	42' [illegible]"	82' 10½"
Mallet (2-6-6-2)..	60,000	440,000	646,000	10' 1"	50' 2"	88' 10"
Mallet (2-8-8-2)..	60,000	540,000	746,000	15' 5"	56' 1"	93' 3"

Where Points of Low Strength May Be Found.—In old structures, it is generally found that the floor systems are comparatively lighter than the girders in plate girder bridges and chord members of truss bridges. The point of low strength in stringer, floor beam and plate girder flanges is generally found at the point of maximum moment, except that where cover plates are used the low strength in the flanges may be found at a point where a cover plate terminates. The flange riveting near the ends of these members very often falls below that required by modern practice. The webs at the point of maximum shear and web splices near the ends of plate girders and the connection of floor beams to the gusset plates, frequently require strengthening in order to produce a structure of uniform strength.

Members of low strength in truss bridges may be looked for in posts and diagonals near the center. The hip verticals very often are out of proportion to other members of the bridge. The end posts and top chords generally show up poorly on account of eccentricity with respect to pins. If the pins of a truss bridge should be calculated according to the accepted practice for designing truss pins, these pins would, almost without exception, show an extremely low rating.

In addition to the weak points in the design, the top flanges of stringers, deck girders and floor beams very often suffer from corrosion due to brine dripping and in bridges where the ties are supported on shelves, the shelf angles frequently are considerably weakened from corrosion. Overhead bridges are subject to excessive corrosion, due to smoke and gases, and this condition is further aggravated where these structures are covered with a solid floor, which prevents the smoke and gases from escaping, and also prevents the steel from drying out quickly; in cases of scant clearance, metal bridges may show excessive deterioration from the sand-blasting effects of cinders. This is especially the case where overhead bridges are located on an ascending gradient.

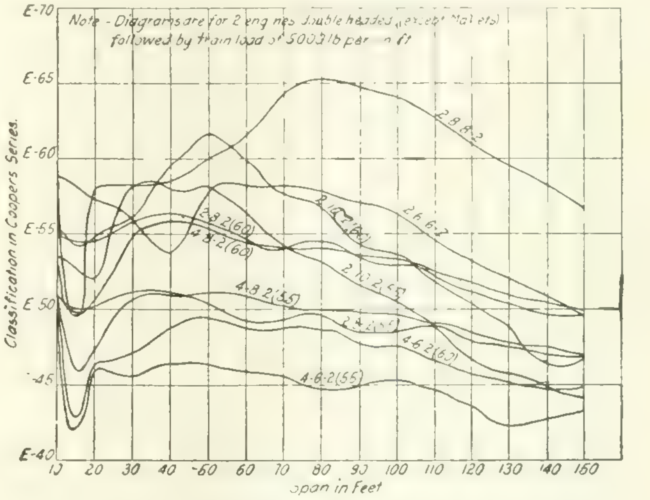

Fig. 3—Comparative Bridge Stressing Effect of U. S. R. A. Standard Locomotives.

Relative Economy of Replacement and Strengthening.—In maintaining old bridges, the question arises whether it is more economical to strengthen the structure than to renew it. This to a great extent depends on whether the old structure can be used to advantage on a branch line or is relegated to the scrap pile. On most large railroads there are branch lines carrying lighter traffic and requiring much lighter locomotives than on main lines; this condition makes it possible to remove bridges too light for main lines and use them on branch lines. Frequently the bridge will be quite suitable for branch line service without strengthening, although it will at times be found desirable to strengthen the bridge before it is re-erected in its new location, when this can be done more economically than while in service. Bridges which are too light for branch line service or which for other reasons cannot be so disposed of, can frequently be used in highway overhead structures.

As a general proposition, the yearly amount of money that it would be permissible to spend for strengthening would be equal to the interest on the investment in a new bridge less the cost of additional maintenance required by the old bridge on account of the greater attention it receives.

For illustration, consider a few lengths of through spans designed for E-55 loading, replacing similar spans designed in the early nineties, the new steel work being taken at 5 ct per pound erected, falsework at [illegible] per [illegible] foot, removal of the old structure at [illegible], salvage on old span at 2½ ct. per pound, additional cost of maintenance of the old span on account of additional inspection, classification and supervision required, $1 per foot of span per year. The last column of the following table shows the amount which we could afford to spend per year in strengthening old spans rather than to renew them. The costs shown in this table are for illustration only. As they fluctuate from time to time, the resulting economies will vary accordingly.

RELATIVE ECONOMY OF REPLACEMENTS AND STRENGTHENING.

Span	New steel. Weight pounds.	New steel. Cost erected.	Salvage.	Net cost.	Interest on net cost at 5 per cent.	Available for strengthening each year
50 ft.	[illegible]	$ 1,[illegible]	$ 1,1[illegible]	$ [illegible]	$ 160.00	$ 110.00
100 ft.	[illegible]	13,[illegible]	5,[illegible]	[illegible]	[illegible]	380.00
200 ft.	800,000	46,800	12,500	34,300	1,715.00	1,515.00
300 ft.	1,600,000	92,200	25,000	67,200	3,360.00	3,060.00

With old and light bridges a limit is reached beyond which it is not economical to strengthen them, and replacement then becomes necessary. It must be recognized, of course, that a newly designed and heavy structure is preferable to a lighter one. It is possibly true that in case of a train accident on a bridge, a lighter structure might be destroyed while a heavy new structure might withstand the same treatment without being seriously disabled. Such considerations must be taken into account in shaping the general policy of keeping lighter bridges in service.

Killing Molds on Lumber by Steaming

Molds thrive on the surface of wood when it is moist and warm. In a dry kiln molds often develop on the surface of the lumber to such an extent that they seriously obstruct the circulation of air through the pile. This is such a decided hindrance to successful kiln drying that steps must be taken to prevent the mold growth. Various experiments have been made by the Forest Products Laboratory to find a means of accomplishing this result without injury to the lumber.

The safest method found of stopping the growth of mold on lumber in a kiln is to steam the stock at 170 or 180° for a period not exceeding an hour. This treatment heats the surface of the stock sufficiently to kill the mold, and at the same time the saturated air prevents too rapid surface drying, so that the injurious effects which otherwise would be produced on the wood by such high temperatures are avoided.

Unless it is desired to relieve drying stresses at the same time, the interior of the stock should be heated as little as possible. Therefore, the steam supply should be sufficient to reach the desired temperature in 25 or 30 minutes. To accomplish this result, plenty of live steam at a pressure of at least 70 lb. gauge must be available. The size of supply line and the number and size of perforations that may be required in the steam jet line will vary with local conditions; it is impossible to make them too large or too numerous, as the quicker the steam is supplied the better the effect.

Care should be taken to see that the stock cools in nearly saturated air. Otherwise the surface will dry too rapidly, and casehardening difficulties will set in.

Ignition Points and Spontaneous Ignition.—The U. S. Bureau of Standards receives frequent inquiries relative to the ignition points of materials and the fire hazards incident with their storage and use, and a few determinations have recently been made in response to specific requests. The average value for a type of newspaper stock was found to be 330° C., ignition occurring after between 2 and 3 minutes exposure. For nitro-cellulose motion picture film, values from 190 to 210° C. were found, after exposures ranging from 3 minutes to one-half minute, the lower temperatures being generally incident with the longer exposure periods, although the method used did not permit determining the relations definitely. The results range about 20° higher than in determinations previously made on celluloid (Technologic Paper No. 98). While little experimental data are available, fire records indicate that the ignition point of a large number of combustible materials is greatly lowered by long time exposure. Fires in textile fabrics, wood, and wood products have been attributed to temperatures not much in excess of 100° C., although there is possibility in many cases that [illegible] other [illegible]

Elimination of Waste in Building Industry*

By SANFORD E. THOMPSON,

Of Thompson & Lichtner Co., Industrial Engineers, Boston, Mass.

Certain waste stands out sharply in the building trade:

1. Loss of working time throughout the year.
2. Poor planning of construction work, and of the individual jobs by the builder.
3. Lack of knowledge of a day's work.

A man's earnings are not what he earns in a day, but what he earns in a year. We must eat while idle; we must sleep in our house whether we work or not; we must wear clothes, and, in fact, better clothes, when we loaf. But, and this is the pinch, a man must earn what he is paid for. How easy it would be if we could pass a law that every man on this continent should receive a salary of not less than $3,000 a year. It can't be done until each man earns his salary of $3,000 per year. We can't draw without putting in.

If Robinson Crusoe fails to plant his corn, he will go hungry for bread; if he builds a house with a leaky roof, he will get wet. He gets in proportion to what he puts in. We, in these big United States, are merely a group of Robinson Crusoes. In the long run, we reap what we sow, we earn what we put into a job.

Wages in the United States are the highest in the world. Why? For one reason and only one reason. The American through his energy, his ability, his get-there, and the natural resources of the country, produces more than does any other nation on earth.

And yet I am prepared to say not as snap judgment, not as mere spectacular talk, but as a result of my knowledge and experience in industrial matters, that if we could eliminate the waste in industry, the wages and salaries of every man in this auditorium could be doubled.

Low Production—Cause of Poverty.—In India and China wages are low. A skilled laborer earns scarcely enough to buy his rice and his strips of cloth to use as clothes. A skilled painter receives one rupee, or 29 ct. a day, perhaps one-thirtieth of our present rate in America. We would hardly call that a living wage, but it is all that he can earn, because he does less than one-thirtieth of the work of the American. It is this low production that is the cause of India's poverty. India and China will continue poor just as long as this low production continues. But we see signs of better things; in India and China textile mills are springing up; other industries are developing work by machinery, which means greater accomplishment per man. We find an incentive and interest and increased production in the manual labor. And soon, we will find the natives buying clothes, living in houses instead of huts, forgetting their harrowing periods of famine, and even getting some of the joys out of life that can only come through prosperity.

In England a writer some year ago showed conclusively through undisputed facts, that the cause of England's poverty was low production. He showed that the productive capacity per man in the United States was at least twice (this took account of machinery, and power, and raw material) that in Great Britain.

We often think if every man could work every day in the year, we would all be on easy street. While vitally important, this is not enough. The Hindoo under his present condition, would still be poor even if he worked every day in the year. The work that is being done must be effective.

Wages and Standards.—And so, we finally must come right down to brass tacks. We find that we must dovetail all these things together, so that every man can have the opportunity to work; we must develop the technique of each industry, so that every man can make the best use of his powers; we must train the employer to plan his work and also to appreciate the human side of life to realize that it is not sufficient to follow the principle that a man may be told any day at 5 o'clock that he can go and get his money.

But probably many of you are saying to yourself, just at this point, this is all very well, but I am out of a job; what good is all this talk about wages and standards. What is the cause of our depression; why don't we start up and go to work, why doesn't this frightful lack of housing make people get busy and build? Many of the explanations we see to this are entirely off their base. The reason is dollars and cents. The textile trade is starting up. Why? Because dealers and cotton men, manufacturers and workmen have taken their losses and the wholesale price of cotton cloth has dropped some 50 per cent. It is selling only 15 per cent to 25 per cent higher than before the war.

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*Abstract of address delivered at a public meeting in Philadelphia April 8, called by the Council of the Associated Building Trades.

Co-operation Necessary to Reduce Costs.—The building business will start up just as soon as we can find some way to reduce costs, so that rents and prices of houses can be lowered and you, and you, and you, as the consumers can afford to hire or to buy the house you want. If we can find some way, and it must be done by co-operation of all concerned, to reduce the cost of brick, to lower still further the price of lumber, to reduce through some of the ways you are working on here, the cost of labor; if, or as soon as, in other words, we can eliminate the waste that these things represent, we will find the owners of buildings ready to start work, we will find the bankers ready to advance money. And, mark my words, there will be no great increase until this reduction in cost takes place.

All this is easy to say. I want to illustrate more constructively by reference to what is being done in one or two other industries. You may say, it is a long way from making clothes to building houses, but, as a matter of fact, the same principles apply. The clothing trade is seasonal, like the building trades, more so, if anything.

What Has Been Done in the Clothing Industry.—Some years ago we made a study for the manufacturers and union, acting jointly, of one of the clothing trades in Boston, to find the average yearly wage of the operators. We found that during nearly one-half of the year only one-half of the force was at work. Again, in the manufacture of clothing, investigation shows lack of any exact knowledge of what should be done in a day on different classes of work. We find poorly set piece rates, which resulted finally in the throwing out of piece rate payments altogether. We find lack of care in the distribution of work to the men and women, resulting in loss of production. We find an increase of 140 per cent in the labor cost during the last few years, at least one-half of which was due to less efficient production. These are some of the causes that last year more than doubled the cost of your suit of clothes.

Now, what is being done in the clothing trade toward curing these conditions? Things which should eventually make for big results are being undertaken. As one distinctive feature, we find a few manufacturers who are finding it possible, through development of their sales which in turn were made possible by reduction in cost of manufacture, to maintain production nearly uniform throughout the year. This is being done in the Clothcraft Shop of Joseph & Feiss in Cleveland. It is being done by A. Nash & Co., in Cincinnati. As another feature of equal importance, is the establishment of standards, the determination of the most economical method by which each operation can be performed and of the fair times to perform this. What does this do? It shows, for example, that on the operation of pressing, by changing the method of handling the work but not increasing his labor, a man can press nearly twice as many coats as before and just as satisfactorily. It shows that by distributing the work to avoid delays, a loss of time waiting for work, which may amount to as much as 10 to 15 per cent of the time, can be avoided. It shows that in cutting, enough material can be saved to appreciably reduce the cost of the cloth.

In one plant in particular, through thorough study and development, it has been possible with the co-operation and consent of the workers (who in this plant are unionized) to pay weekly wages in accordance with the achievements of the standards set. The result is not simply a reduction in the cost of manufacture through changes in methods and standardization, although this has taken place to a large degree. It is not merely a maintenance of a wage nearly as high as formerly, although this is a fact. But of even greater moment, is the elimination of the constant friction between the manufacturer and the worker, because it has been found possible to substitute facts for guesswork. This has produced a spirit of co-operation and harmony that has completely relieved the very tense labor situation which formerly existed. It is all of these things that will tend to reduce the price of your suit of clothes.

How Results Can Be Produced in the Building Trades.—Now, how can these principles be applied to the building trades? How are we to maintain or, if they drop now, to reach again our high wage mark? Notice that you have in building conditions similar to clothing manufacture—irregularity of work throughout the year, often poor planning of the work, and also lack of knowledge of what is a fair day's work. There is but one way. It is to eliminate the waste of time and of energy and of material. If a builder fails to plan his work and his men are idle, it may not cost him any more on that particular job, but it means the workmen eventually must be paid more per day to balance his loafing time, and the cost of building is increased and fewer people can build. If a bricklayer loafs on his job and restricts his production, it will not affect his pay at the end of that particular day, but it is wasted time. It increases the cost of the job, and fewer people can build.

I have gone into these things in detail because they are so vital and because I want to encourage you in the good work you are doing here in Philadelphia. Two particular things that you have proposed—the development of planning and scheduling work and the determination through co-operative effort of standards of methods and procedure reach furtherest down into the fundamentals of waste elimination than anything that has yet been attempted by any group or in any locality.

I can speak more freely here in Philadelphia than anywhere else, because it is the only place I know of where even a thought has been given to the application of some of the principles which can, and will, by persistent and constant attention produce results in the building trades which are entirely omitted at any certain industry.

Brick Laying Standards.—I am going to tell you a little of some of the work that I have been doing along these lines. A number of years ago in collaboration with Mr. Frederick W. Taylor of your city, I began a study of the operations in the building trades. At a recent hearing in Boston before a committee of the Chamber of Commerce most distinctive statements were made of the falling off of the work of bricklayers during the past few years. Statements were made that men were laying one-third the amount of brick, or less, than formerly putting in a wall. The answers from the labor side refer very fairly to the variation in the labor for different kinds and thicknesses of walls, but no facts were presented on either side which would really either prove or disapprove the statement.

I have here a table made up sometime ago, showing the number of brick that a bricklayer lays under ordinary conditions in an 8-hour day on different kinds of walls. I find here a range in ordinary building construction of from 2,900 brick per day for heavy backing in rough work down to 145 brick per day for Roman pressed brick on fine city house fronts. Now, this difference is due not to difference in scale, not of soldiering, not even to difference in method of managing the work, but solely to the nature of the wall. Some of you who like figuring, might figure this up in percentages and bring out the astonishing fact that one man laid 2,000 per cent more brick than the other. You might go even farther than this, however, and cite the still larger number of brick per day that are sometimes laid in heavy sewer construction. I would not dare figure this up in percentages.

Now, referring again to the table, we find that for an 8 in. blank wall the rate is 940 brick per day, while for the same wall with occasional openings, the same man ought to lay only 760 brick per day. Again, the same man on a 16 in. blank wall should run up to 1,320 brick per day, or if the 16 in. wall had occasional openings, he will drop back to 1,130 brick per day.

Determination of Standards in Building Construction Operations.—I wish that I had more time to go into some of the details and show how it is possible to figure such work and get accurate results. The best proof that it can be done lies in the fact that it has been found possible on most intricate building construction, where there were steel columns surrounded by small piers of brickwork in one part of the building and plain, ordinary walls in other parts, to accurately figure in advance the time that ought to be taken in each case. The principle adopted in making these determinations was identical with the principle used in the clothing analyses referred to. In clothing we found the time, for example, to sew a seam per inch of length, to turn points, to change garments, and so on. In bricklaying the studies were made on the unit times of laying the individual brick, cutting the brick, laying the lead, stretching the line, joining, changing from one job to another, and so on. By combining these units to suit the different walls, it was possible to figure it up in advance so that one could tell the amount of work that should be done by the average bricklayer. With such information as this, such fact of what can be done, one has a foundation for development of standards which go far toward containing the results we are all aiming for.

I might go farther than this. We might take up carpentry; show how by these same means it is possible to designate the time for laying floors in different sizes and shapes of room accurately, show how and why it takes twice as long to fit and hang one kind of a door than another. Similarly, we might show how even plastering can be accurately figured for different sizes and shapes of rooms.

You may ask why studies of details, why the determination of standards will aid in eliminating waste. It is because it will increase the initiative of the worker, it is because it will differentiate the good man from the poor man, it is because it will present an aim to work for, it is because, and this is perhaps the most important feature of all, it will show up the easiest and the most economical way of doing work and will compel employers to take more thought of the methods of handling the work and in planning out the work that is to be done.

Thus, costs can be and will be reduced. Thus, will be made possible and only thus, a gradual increase from year to year in the wages, in the number of days per year work, and specially in the elimination of friction which is so often caused by lack of knowledge of facts.

Investigation of Body-Bound Bolts.—The U. S. Bureau of Standards has been conducting an investigation on the experimental use of liquid air and an explosive charge for body-bound bolts. The request for this work came from another government department and if the practical application of the methods proves successful, such bolts would be of considerable value in certain situations. Two methods of obtaining a tight fit between the bolt and the material surrounding it were used in an effort to find one which would give sufficient strength under severe shearing stresses. The first method employed liquid air, while in the second an explosive was used. In the first method the bolt is immersed in the liquid air until it has contracted sufficiently to allow it to enter the holes in the plates. As the bolt warms, it expands, resulting in an extremely tight fit. In the second method, the bolt is inserted as a loose fit and has a small hole along its axis in which an explosive charge is placed. When this charge is fired, it expands the bolt rendering it a tight fit. Before the two methods above mentioned were tried, experiments had been made on cylindrical pins which were from 0.001 to 0.0015 in. larger than the holes and which were contracted to fit the holes by immersing in liquid air. Tests had also been made on tapered pins which were contracted in the same way and driven into tapered holes. The results of the investigation on the use of liquid air showed that a tighter fit can be obtained with tapered pins than with the cylindrical pins. The average unit frictional resistance as shown by the tests on cylindrical pins was 2,150 lb. per square inch, while the average value for the tapered pins was 3,000 lb. per square inch. The test of the bolts expanded by explosive charges shows that satisfactory results can be obtained by the method as the average unit frictional resistance was 2,150 lb. per square inch. The tightness of the fit is dependent upon the size of the hole bored in the axis of the bolt to contain the powder charge as well as upon the pressure of the explosion.

National Electrical Safety Code.—Handbook No. 3 of the U. S. Bureau of Standards has recently been published and may be obtained from the Superintendent of Documents, Washington, D. C., at 40 ct. per copy. This new edition is a book of pocket size and the discussion of the rules has been segregated in a separate volume which will appear later as Handbook No. 4. In addition to two introductory sections giving definitions of terms and rules for the grounding of apparatus and circuits, the code consists of four principal parts as follows: (1) Rules for the installation of machinery, switchboards, and wiring in central stations and sub-stations; (2) rules for the construction of overhead and underground lines for the transmission and distribution of electrical energy and intelligence; (3) rules for the installation of electrical apparatus and wiring in factories, residences, and wherever electricity is utilized for light, heat, or power; (4) rules for safeguarding employes when working near electrical machines or lines.

Difficult Roof Reconstruction Accomplished by Use of a "Cement-Gun"

By L. R. TALBOT and GEO. P. TRAX.

In solving a problem in roof reconstruction at an eastern chemical manufacturing plant, the "Cement-Gun" played an important part. The job consisted in removing and replacing the roofs on fourteen buildings between Oct. 1 and Dec. 31, 1920. As the buildings housed chemical processes which were in operation and could not be disturbed, the problem presented many interesting features, one of which was to accomplish the desired result by some medium affording a minimum of interference with operation.

The buildings were covered with cement tiles, most of which had been in place from 6 to 8 years, and had deteriorated badly, this being attributed to general weathering, aided by escaping gases from chemical processes.

In replacing the roofs, it was deemed advisable to provide some fireproof material on eight of the roofs, the other six were to be covered with timber on account of the ease with which it could be placed. Of the schemes considered for the eight roofs, which were to be re-roofed with a fireproof material, the first was that of a 4 in. reinforced concrete slab. This thickness was taken, not so much for the structural length, as for the assurance of a sufficient envelope of the reinforcement to protect it against similar destruction. Along with this scheme, it was proposed to remodel the roof frame into a series of sawtooth-like sections whereby flat pitches could be obtained, avoiding the necessity of having double forms for the pouring of the concrete slab.

Another scheme considered was to pour the concrete slab on the existing roof structure. On account of the steep pitches, double forms would have been necessary. This was an objectionable feature and would have been a great handicap in the execution of the work.

After a thorough investigation both of the proposed schemes were discarded, being considered impractical, for by the time new steel could have been fabricated and erected several months would have elapsed, throwing the work well into the winter season. To pour the slab on the existing roof structure would have entailed the use of double forms, and the maintaining of a large crew of form setters. Due to the location of the buildings, which in almost every case were surrounded by tanks or other structures, it also would have been necessary to provide an elaborate placing plant, either tower and chutes, or runways and buggies, all of which seemed unjustifiable for the amount of work to be done.

The "Cement-Gun" was then considered and adopted as being the most feasible method under the existing circumstances on account of its very simple arrangement for transporting the material from the ground to the roof through a hose by pneumatic pressure. Also a thinner slab could be placed, using only a light single form on the under side, and gunite could be placed with a minimum of hydration resulting in very little leakage into the building below. This latter was a most important feature as it was necessary to protect operations within the buildings. Having the assurance of securing the apparatus without delay meant that work could be commenced immediately which was a decided advantage in view of the approaching winter season.

Because of the tendency of rapid deterioration around chemical plants, and in view of the fact that the gunite slab was thinner than the proposed concrete slab, it was decided, as an additional precaution, to cover the slab with a roofing material.

Of the total area of 70,000 sq. ft. to be covered, approximately 40,000 sq. ft. comprising eight roofs, were covered with a 3 in. "gunite" slab, the remaining six roofs being covered with 3 in. splined yellow-pine plank. The engineers of the Cement-Gun Company, Inc., thought that a 3 in. slab was thicker than necessary, but since there were no prior examples in this locality of gunite roofs under such trying conditions, it was thought that it would be wiser to provide this additional thickness to the slab.

The original roof supports consisted of 6 in. I-beam purlins spaced 48 in. on centers and carried by trusses on 12 ft. centers. The forms were therefore made up in panels, a sufficient number being made to serve for two of the eight buildings, thus allowing the forms to remain in place for more than a week and still provide continuous operation of the "Gun." This was advisable due to prevailing temperatures.

The form panels were made of 7/8 in. matched lumber in 2 ft. by 6 ft. sections. Two sections filled the space between adjacent purlins, and were supported by 2 in. by 4 in. pieces resting on the bottom flanges of the purlins. This brought the top of the panel about ½ in. below the top of the purlins and by placing the reinforcing mesh ⅜ in. above the purlins insured a complete envelopment of the reinforcement. The forms were placed from the under side of the roof before the tile was removed, thus reducing the amount of scaffold that would have been necessary and affording protection to the men and apparatus below from falling fragments. This method necessitated great care and resulted naturally in a higher cost for form work.

Owing to the slope of the roof, it was deemed advisable to provide nailing strips for the roof covering, accordingly 1¼ in. by 1½ in. cypress beveled strips were imbedded in the slab. To insure that these strips and the reinforcement were at the proper elevation and that no metal projected near the outer and inner surfaces of the slab, 3/8 in. by 2¼ in. iron dowels were set in holes ½ in. deep, drilled in the top of the purlins over the web. This drilling was done with an electric drill, using a stop on the bit to limit the depth. Corresponding holes were bored in the under side of the wood strips which were placed on top of the dowels and thereby rigidly held at the proper elevation.

The reinforcement, which was expanded metal 3 in. by 8 in. diamond mesh, having a sectional area of 0.15 sq. in. per foot of width, was laid on the purlins before the wood strips were placed, the forms first being covered with roofing felt to give a smooth continuous surface. As it was found that the one ply felt wrinkled from the force of the blast and also stuck to the under side of the slab, this was changed to a two ply ready roofing which was stiff enough to lay flat, and having a smooth oily surface came free when the forms were stripped. Also, having body, it was undamaged by removal and was used repeatedly. The crew placing forms and reinforcement also removed the old tile, this work of stripping being so regulated as to be not more than a half day ahead of the "gun" so that at night, or during inclement weather a minimum of open roof had to be protected.

The reinforcement originally intended for the concrete work was 3/8 in. round rods and after "gunite" was adopted, this same method of reinforcing was employed, for the first few days. It was soon seen, however, that not only was this unnecessarily laborious but also added to the cost. Calculations indicated that the expanded metal used was heavier than necessary. Still it was thought advisable to add a factor of safety.

The gun was placed as close as possible to the job, and so located as to be accessible for teams. It was set up on a plank platform about 20 ft. square with a shelter built over it. It was found that as long as the material was kept dry at the gun, work could go on even in very damp and drizzly weather.

A mixture of 1 part cement to 3 parts sand was used and prepared as follows: A box with no bottom, 1 ft. deep and 3 ft. square was made with projecting handles. This was filled level with sand and three bags of cement added, the box was lifted off and the material turned once by hand and then screened through a 3/8 in. mesh screen. The resulting mixture was shoveled into a hopper over the gun and pulled into the machine by the operator as needed.

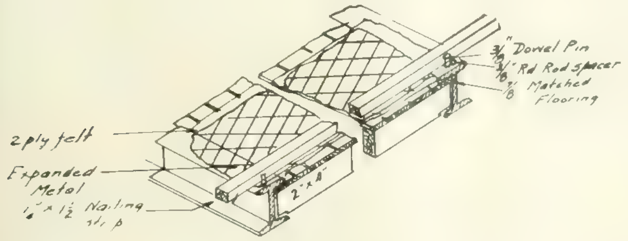

Fig. 1.—Method of Placing Forms.

Due to the rainy weather difficulty was encountered at first by the sand being too wet, and as covering with canvas was not sufficient to keep it in proper condition, a steam coil made up of return bends and eight or ten pieces of 1¼ in. pipe was run through the sand pile. By keeping the sand pile covered with canvas, and by aid of the coil, sand was obtainable at all times with the proper degree of moisture, regardless of the weather. Another advantage of the coil was that when the nights were cold, it gave the material an initial heat, and as the water and air were heated by keeping a fire in the "Dewey heater and dryer," there was no difficulty in placing the "gunite" during reasonable temperatures. All the buildings were warm inside from the piping, and at night, by covering the last few feet placed with tarpaulins, ample protection against the injurious effects of freezing was obtained.

The "gunite" was placed in one coat working downward along the roofs. As the nailing strips were fastened up and down the roof on 30-in. centers, the material was accordingly placed in strips 30 in. wide. A light protecting shield about 18 in. high was set up on the finished work and moved ahead as the work progressed, thus keeping the finished surface free from rebound. The surface was cut down flush with the top of the nailing strips with a steel cutting edge made of 3-in. x ⅜-in. steel, thus leaving a flat surface for the application of the roofing. The only additional work necessary was to hose off or sweep the roof.

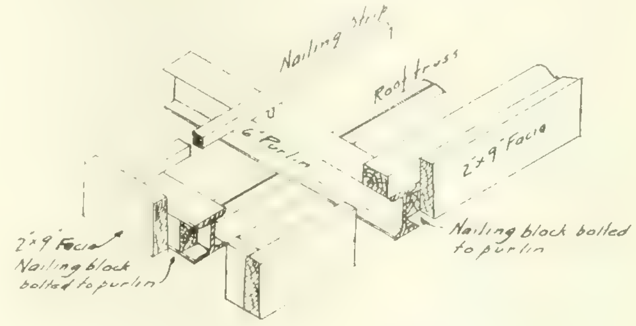
Nailing strip
Roof truss
6" Purlin
2"x9" Facia
Nailing block bolted to purlin
2"x9" Facia
Nailing block bolted to purlin

Fig. 2—Method of Finishing Edges and Ends of Roof.

Due to the fact that the slab was placed on a slope, two nozzlemen were used. These men changed off, the spare man cutting down the surface of the slab, while the other handled the nozzle. A laborer was also used on the roof to carry the slack of the hose behind the nozzlemen. No scaffold was provided for these men, but a knotted rope was attached to the ridge and used to support them. As mentioned above, the location of the buildings necessitated forcing the material through unusually long lengths of hose with a consequent diminution in quantity of gunite placed. The longest length used was 450 ft. Gutters were brought to grade by stretching a line a fixed distance above the gutter and using a grade stick in a manner similar to laying sewer pipe.

Gunite work was commenced Oct. 26, 1920. During the last five days of this month, weather was fair. The daily average output was 760 sq. ft. of 3-in. slab per day.

The month of November showed the greatest progress. The weather conditions for this month were generally fair, the average mean temperature being 46° F. with the lowest temperature 39° F. Occasional showers delayed the work somewhat but not to an appreciable extent. Four Sundays, one holiday and two rainy days reduced the working time in this month to 23 working days. In computing the output, a day was counted as a full day if the "Gun" started, even though it worked only a very short time. The daily average of "Gunite" placed during these 23 days was 887 sq. ft. of 3-in. slab, and the best single day's run was 1,240 sq. ft. for a 9-hour day, including the time spent in getting started in the morning and cleaning up at night. For seven of the 23 days, the daily output was well over 1,000 sq. ft.

During December progress was retarded somewhat. The days were shorter and the nights were cooler, making it necessary to shut down in time to cover up materials and drain out the hose and pipes. It was also not possible to get as prompt a start in the mornings. The average mean temperature for the month was 40° F. with the lowest temperature 34° F. Four inches of rain fell during the month, being divided about equally between day time and nights.

Deducting four Sundays, one holiday and two days of unfit weather, 24 days' work was accomplished, with an average daily output of 606 sq. ft. of slab 3 in. thick. Another factor entering into this month's work which reduced the average was the fact that all the work done during the month was on buildings with a steeper roof pitch, at least 20 ft. higher from the ground than those w[illegible] November, meaning an additional head of 20 ft. that the "gun" had to work against.

From Oct. 26, when work was started, until it ceased on Dec. [illegible], there was placed a total [illegible] of "gunite" slab 3 in. thick, or in 52 working days there was a daily average of 745.3 sq. ft. per day.

The total materials used were 4,730 bags of cement, and 14,190 cu. ft. of sand, and average of 8.2 sq. ft. 3 in. thick to every bag of cement. The loss of reinforcing mesh area due to lapping was 11 per cent.

The crew which removed the old tile roof, erected and stripped forms, placed paper and reinforcement, consisted of a foreman and an average of eight carpenters, with the services of four or five laborers about one third of the time to dispose of the old tile. The "gunite" crew consisted of a foreman, a gun operator, and five laborers to serve the "gun," one shoveling into the hopper, three turning and screening, and one handling cement and empty bags. On the roof were two nozzlemen and one laborer, making a total "gunite" crew of nine men.

Air was supplied to the "gun" at 80 lb. pressure from a compressor and receiver set up in the power house near the center of the plant. It was piped to the "gun" through an independent 2-in. line, pressure being reduced to the proper amount at the "gun." Water pressure of 100 lb. was obtained from the fire system.

The "gun" used was the standard N-2 machine furnished by the Cement-Gun Co., Inc., of Cornwells, Bucks County, Pennsylvania, fitted with their standard equipment.

Figure 1 shows the method of placing forms, and in this connection it will be noted that a small heel strip was placed to keep the mortar from running under the flange of the I-beam purlins, preventing a ragged fin which would later require removal.

Figure 2 shows the method of finishing the edges and ends of the roof with a piece of 2-in. x 8-in. bolted to the purlins in such a manner as to bring the top flush with the finished "gunite" and giving opportunity to fasten the roof covering.

This work was executed for the General Chemical Co. at its Delaware works by the J. G. White Engineering Corporation, 43 Exchange Pl., New York, N. Y., as a part of the 1920 program of new construction and repairs. Mr. Arch Robison was General Superintendent on the job for the J. G White Engineering Corporation, the writers being directly in charge of the work as field superintendent and engineer, respectively.

Massive Falsework for Carying Large Reinforced Concrete Trusses.—What is believed to be the largest falsework ever used in California on a reinforced concrete building is being employed in the construction of a theater building in Southern California. According to an article in California Safety News by Mr. J. J. Rosedale, construction engineer of the California Industrial Accident Commission, 500 M ft. B.M. of selected Oregon pine is being used to erect the falsework which will support 8 large girders over the stage and 10 trusses 16 ft. depth, space 12½ ft. c. to c. and spanning 126½ ft. over the auditorium. Each truss will weigh 660 tons. This wooden structure consists of 100 12-in. by 12-in. columns under the auditorium and 67 similar columns under the stage. These columns are 90 ft. high to the outside of the girders and rest on heavy concrete footings which will be used later to support the auditorium floor. These columns are braced rigidly by 3-in. by 10-in. and 3-in. by 12-in. timbers, which are all fastened by ¾-in. bolts. Every precaution is being taken for the safe construction of this falsework, and only the very best material is being used. There is a 5-ft. covered stairway leading from the ground to the top of the false-work, and additional platforms and safety stations equipped with standard railings and toeboards are provided for the safety and convenience of the 250 workmen engaged on this structure. The top of the false-work is covered with 2-in. planks laid closely together. Two concrete mixing plants are located at each end of the building, and it is proposed to pour each girder at one time. One of these mixing plants will be used only in an emergency, in the event the other should break down. The capacity of this theater will be 4,400. It will be one of the largest movies west of Chicago. A 6-story office building is being constructed above the theater. The work is under the direct supervision of Edwin Bergstrom, architect, and R. C. Mitchell, engineer.

Proposed Federal Legislation to Stimulate Construction

Ten measures for stimulating and fostering the development of construction work are recommended for legislative consideration by the U. S. Senate in the report of the Senate (Calder) Committee on Reclamation and Production. This report was submitted to the Senate on March 3 by Senator William M. Calder, chairman of the committee. The following summary and description of the measures prepared by the committee are abstracted from the report:

(1) A bill to establish in the Department of Commerce a division for the gathering and dissemination of information as to the best construction practices and methods, technical and cost data, and matters relating to city planning, etc., in order to encourage standardization and improved building practices throughout the country.

Services Building Bureau Could Render.—It is not enough that homes be built; they should be built well and economically, and the subdivisions of the cities in which they are built should be laid out according to modern ideas of city planning. It is appropriate that the Federal Government, with its wide connections abroad, with its opportunity to co ordinate the experience of all of the states, should establish in Washington a bureau or division where builders and city planning committees can secure the most recent information on the construction of houses. The Federal Government has, furthermore, during the war, collected a vast amount of information and accumulated considerable experience in respect to building and city planning through its own building activities. This information should be preserved and ordered, and will then form the nucleus, at little expense, of a valuable collection of information. This is a service which the Government can render to its people without danger of paternalism.

There is another important service which this bureau or division can render. At the present time there is a great variety of requirements in the building codes of the different cities and states. A study of these codes and experience under them would be of great service in preparing the material for the drafting of a building code which would be as nearly uniform as the varying conditions in the different cities would permit. The proposed bureau could serve as a clearing house for information in respect to the experience of the different cities, so that amendments to codes and new drafts of codes could be prepared in the light of the collected experience of the whole country, and not as a result of purely local consideration. As a result of the variety of the requirements in building codes, it is not possible to carry through the standardization of building materials which is so desirable and which would cheapen the cost of construction. A great saving in building throughout the country could be secured by careful study of building construction and standardization of building materials (similar to the work done by the Bureau of Standards in other lines); but a necessary part of this work would be the preparation of model building codes, which would make possible the use of the standardized material. In proportion to the advantage gained the cost is slight, especially as the nucleus of the collection is already in existence, and the result upon the comfort of American homes and the beauty of American cities will be worth striving for. Another use for the material collected by this bureau might be the preparation of a model building code for the District of Columbia, which might be available for adoption with necessary modifications by cities throughout the country.

(2) A bill designed to provide for the gathering and publication by existing governmental agencies of current facts as to production, distribution, available supplies, standards of quality, costs, and realization of coal.

Statistics Regarding Coal.—On power, and power is generated in the main by coal, depends building construction, as indeed the whole industrial life of the nation.

Wisely to act in control of interstate and foreign commerce, fairly to conserve the interest of the public without injury to those of coal miners and operators, the legislative and executive branches of the Government need systematically gathered and carefully analyzed statistics of the fullest sort in respect to the coal industry. Experience has shown the difficulty confronting conferences called by the Executive and by committees of Congress in securing quickly satisfactory information upon which to base conclusions.

There is another reason why all such statistics should be gathered and published. The public, irritated over the high cost and unsatisfactory supply of coal and the high railway rates (in part dependent upon the cost of operation, of which fuel cost is a large factor), is entitled to know whether the burden put on every householder and every manufacturer is fair, or whether profiteering is going on, and it turns, not to the government of the states, but to the Government of the nation for its information.

(3) An amendment to the transportation act directing the Interstate Commerce Commission not to declare without hearings an emergency which will give preference or priority in transportation.

Transportation of Building Materials.—Transportation of building materials is not mainly intrastate but interstate, over which the Interstate Commerce Commission has control. That commission, by its priority orders, has delayed the carriage of structural material, and has therefore rendered more hazardous and expensive, through unforeseen delay, the already hazardous and expensive business of building construction. The committee recommends that the authority of the Interstate Commerce Commission to issue priority orders, without the formality of a public hearing, be removed.

(4) An amendment to the federal reserve act to permit the Federal Reserve Board to direct the use of savings and time deposits of national banks for long-time loans, thus giving such deposits greater security and supplying a source of long-term money for home building.

Supplying Long-Term Money for Home Building.—The Federal Government has already assumed a degree of control over the credit facilities of the country through the national bank and Federal Reserve acts. It has furthermore come to the aid of the farmers of the country by establishing farm loan banks, which open new avenues of credit to the basic industry of agriculture, and has provided credits for the export trade through the extension of the War Finance Corporation. By the creation of savings departments in the national banks it has brought within the control of Congress a large share of the savings of the people. The committee is therefore only following a beaten path in proposing a bill to authorize the investment of a part of those savings in mortgages on real estate and in extending to home builders the same credit facilities already put at the service of the farmers and of merchants and manufacturers interested in the export trade. Safe mortgages are the best security for the people's money, and it is appropriate that that money be used to supply homes.

(5) A home loan bank bill to provide for district home loan banks which may sell, under Federal supervision, bonds secured by the aggregated loans deposited by the member banks.

Home Loan Banks.—The bill to authorize the creation of home loan banks follows the Federal Farm Loan act. It federates into regional banks the existing building and loan societies, and enables them to raise money upon the mortgages in their vaults with which to finance new building construction. These societies, true people's banks, have sprung up voluntarily all over the country. They are popularly controlled, locally managed, financial institutions which make loans only to the holders of stock, so that the security under mortgages issued by them is double. Responsibility of applicants is scrutinized by committees of their neighbors. The regional banks proposed will greatly increase the available capital of these institutions by permitting them to use their mortgages as security for the issuing of the loans which they must in turn invest in further home building. As the issues of the loans by the regional banks are to be tax-exempt, like farm loan bonds, and as they are guaranteed by the best of security—mortgages on the homes of the country—they can be easily sold. This bill is a step toward democracy in banking, as well as a means of meeting a pressing national necessity.

(6) An amendment, limited to five years, to the revenue act of 1918, to provide for the exemption from excess profits and income taxes of the profits on the sales of dwelling houses where such profits, plus an equal amount, are reinvested in dwelling house construction.

Exempting Profits from House Sales from Income Tax.—The committee furthermore, following the precedent used in the shipping act of 1920, has drafted a bill to free from income tax for the next five years, the profits from the sale of homes, provided that this profit is reinvested in more homes, dollar for dollar, with new money.

(7) An amendment to the revenue act of 1918 to exempt from taxation interest on loans up to $40,000 on improved real estate used for dwelling purposes, when such loans are held by an individual.

Exemption of Building Loans from Taxation.—A substantial interference by the Federal Government with the normal flow of credit results from the exemptions of interest on the bonds of the United States and of individual states and municipalities from the income-tax law. The result of this exemption has been to limit the flow of capital into building loans and to increase the rate of interest on the loans which are made, consequently limiting construction and increasing carrying charges and therefore the rental of homes. The committee realizes that there is a conflict of opinion among lawyers as to whether or not Congress can, under the income tax amendment, tax the income from the securities of states and their political subdivisions. The courts have not had to pass upon the question, since Congress has thus far not imposed such a tax, and there are grave questions of policy involved. The committee therefore believes that, even if Congress has the power to sweep away these exemptions and thus restore a normal flow to the money market, a long time must elapse before such action will be taken; and the problem of supplying credits to the building industry is a problem of today, not of tomorrow. It must be met, therefore, with reference to the now existing conditions and not in view of what may be done in years to come. The committee, therefore, must make recommendations on the basis of the exemptions now in the income-tax law. The committee believes that the power of Congress to divert the flow of capital by means of income-tax exemptions should be used only when and as long as an imperative need exists, but it believes that its report shows such an imperative need. Congress has the power to exempt from tax the income from a limited investment in mortgages, and thus to encourage individuals to supply the money for home construction. Is it not wiser thus to open the way for private capital and private enterprise than to risk the possibility of direct municipal, state or Government grants to home builders, as in Great Britain and France, with all its attending red tape and risks to the public funds? While the committee recommends a bill to exempt, from the income tax, mortgages to the amount of $40,000 held by any individual, the exemption need not and should not be long continued. As soon as the need is passed, it should be repealed.

(8) An amendment to the revenue act of 1918 limiting the taxation of profits from the sale of capital assets by providing for their taxation as of the years of accrual rather than as of the year of their sale.

The purpose of this amendment is to release for sale property now held because the profit from the sale is charged against the income of the year of sale.

(9) An amendment to the revenue act of 1918 to limit the surtax upon saved income to an amount not in excess of 20 per cent of such income.

(10) An amendment to the postal savings law increasing the limitation on deposits as to amount and time, and authorizing the rates of interest to be changed from time to time and providing for compensation of postmasters for the extra duties.

The purpose of these bills is to encourage saving and investment in real property and to check nonessential spending.

In its recommendations the committee has had in mind the importance of economy. The cost of the collection of the coal information, the cost of the housing bureau, the supervision of the Federal home loan banks, will constitute no appreciable burden on the treasury; the results of the various bills proposed, however, in holding down the price of essential materials, in preventing unfair competition and monopoly in coal, and in directing the flow of credit toward the building industry will, the committee believes, cause the prompt construction of the homes so urgently needed.

Breaking Up Concrete with Oxy-Acetylene Torch.—The work of breaking up concrete in a Cleveland, O., building was speeded by use of the oxy-acetylene torch. The method employed consisted of heating along the line of the desired fracture with an ordinary welding torch, using a long bushy flame. The concrete was not raised to a great heat, as measured in terms of oxy-acetylene, but the heat was confined as much as possible along the proposed line of fracture. When so heated the concrete yielded to a heavy blow of the sledge, breaking off in the predetermined form and bulk.

Index Numbers of Wholesale Prices 1913 to March 1921

The accompanying tabulation shows the index numbers of wholesale prices by groups of commodities as compiled by the U. S. Bureau of Labor Statistics. The group of miscellaneous commodities includes such important articles as cottonseed meal and oil, lubricating oil, jute, rubber, newsprint and wrapping paper, rope, soap, laundry starch, tobacco, Manilla hemp, sisal, phosphate rock and wood pulp. The commodities, including the other groups, are as indicated by the title:

INDEX NUMBERS OF WHOLESALE PRICES IN SPECIFIED YEARS AND MONTHS 1913 TO MARCH, 1921, BY GROUPS OF COMMODITIES.
(1913=100.)

Year and month.	Farm products.	Food, etc.	Cloths and clothing.	Fuel and lighting.	Metals and metal products.	Building materials.	Chemicals and drugs.	House-furnishing goods.	Miscel-laneous.	All commodities.
1913	100	100	100	100	100	100	100	100	100	100
Jan.	97	99	100	103	107	100	101	100	100	100
April	97	96	100	98	102	101	101	100	98	98
July	101	102	100	99	98	101	99	100	101	100
Oct.	103	102	100	100	99	98	100	100	100	101
1914	103	103	98	96	87	97	101	99	99	100
Jan.	101	102	98	99	92	98	100	99	99	100
April	103	95	99	98	91	99	100	99	101	98
July	104	101	99	95	85	97	99	99	97	100
Oct.	103	107	97	93	83	96	105	99	96	99
1915	105	104	100	93	97	94	114	99	99	101
Jan.	102	106	96	93	83	94	103	99	100	99
April	107	105	99	89	91	94	102	99	99	100
July	108	104	99	90	102	93	108	99	98	101
Oct.	105	103	103	96	100	93	124	99	99	101
1916	122	126	128	119	148	101	159	115	120	124
Jan.	108	113	110	105	126	99	150	105	107	110
April	114	117	119	108	147	101	172	108	110	117
July	118	121	126	108	145	99	156	121	120	119
Oct.	136	140	138	133	151	101	150	124	132	134
1917	189	176	181	175	208	124	198	144	155	176
Jan.	148	150	161	176	183	106	159	132	138	151
April	181	182	169	184	208	114	170	139	149	172
July	199	181	187	192	257	132	198	152	153	186
Oct.	208	183	193	146	182	114	252	152	163	181
1918	220	189	239	163	181	151	221	196	193	196
Jan.	207	187	211	157	174	136	232	161	178	185
Feb.	208	186	216	157	176	138	232	161	181	186
March	212	177	223	158	176	144	232	165	184	187
April	217	178	232	157	177	146	229	172	191	196
May	214	177	237	160	178	148	223	173	194	190
June	217	179	245	159	178	150	219	198	196	193
July	224	184	249	166	184	154	216	199	190	198
Aug.	230	191	252	166	185	157	222	221	191	202
Sept.	237	199	255	167	184	159	220	226	194	207
Oct.	224	201	257	167	187	158	218	226	196	204
Nov.	221	206	256	171	188	164	215	226	203	206
Dec.	222	210	250	171	184	164	195	237	204	206
1919	234	210	261	173	161	192	179	236	217	212
Jan.	222	207	234	170	172	161	191	218	212	203
Feb.	218	196	223	169	168	163	185	218	208	197
March	228	203	216	168	162	165	183	218	217	201
April	235	211	217	167	152	162	178	217	216	203
May	240	214	228	167	152	164	179	217	213	207
June	231	204	258	170	154	175	174	233	212	207
July	246	216	282	171	158	186	171	245	221	218
Aug.	243	227	304	175	165	208	172	259	225	226
Sept.	226	211	306	181	160	227	173	262	217	220
Oct.	230	211	313	181	161	231	174	264	220	223
Nov.	240	219	325	179	164	236	176	299	220	230
Dec.	244	234	335	181	169	253	179	303	229	238
1920	218	236	302	238	186	308	210	366	236	243
Jan.	246	253	350	184	177	268	189	324	227	248
Feb.	237	244	356	187	189	300	197	[illegible]	227	249
March	239	246	356	192	192	324	205	329	230	253
April	246	270	353	213	195	341	212	331	238	265
May	244	287	347	235	193	[illegible]	215	329	246	272
June	243	279	335	246	190	[illegible]	218	362	247	269
July	236	268	317	252	191	333	217	362	243	262
Aug.	222	235	299	268	193	328	216	363	240	250
Sept.	210	223	278	284	192	318	222	371	239	242
Oct.	182	204	257	282	184	313	216	371	229	225
Nov.	165	195	234	278	170	274	207	369	220	207
Dec.	144	172	220	236	157	[illegible]	188	346	205	189
1921:										
Jan.	136	162	208	228	152	239	182	283	190	177
Feb.	129	150	198	218	[illegible]	222	178	277	180	167
March	125	150	192	207	139	212	[illegible]	273	167	162

Waste of Lumber for Scaffolding.—In an address April 8 at a public meeting in Philadelphia, held by the Council of the Associated Building Trades, Mr. Albert Kelsey, architect, called attention to the waste of lumber for scaffolding in many jobs. He stated that it is the rule to use new lumber and thin boards, instead of old, seasoned planks, and thus before the job is finished half of this good material is ruined. In Europe a good builder owns thick planks and sturdy poles, which he takes with him from job to job, year after year, and ties them together with ropes. The lumber being of the proper sizes for rough usage, and seldom being nailed, is therefore not damaged, and accordingly serves perhaps for 20 or 30 operations, while ours is seldom used for more than one.

Wage Advances in Building Trades 1914 to 1920

Some interesting information on the extent of wage advances in the building trades is given in the report of the Calder Committee submitted last month to the U. S. Senate. The figures, based on data compiled by the U. S. Bureau of Labor Statistics, are given in the accompanying tabulation, which shows the average increase in union wage rates between 1914 and 1920 in the more important building trades. As the building trades are highly organized in the great majority of communities, the rates paid union workers may be taken as fairly representative. On the other hand, the union scales are what are known as minimum rates, which may be exceeded when the demand for labor is strong. In general, however, the union rates of pay are recognized as being very close to the actual rates prevailing in a given community.

SUMMARY OF UNION RATES OF PAY AND HOURS OF WORK IN VARIOUS CITIES, 1914 AND 1920.

Occupation.	Rate per hour (cents) 1914.	1920.	Per cent increase.	Hours per week 1914.	1920.
Bricklayers	68.2	116.5	70.8	45.2	43.9
Carpenters	50.8	99.7	96.3	45.6	44.1
Cement workers and finishers	59.3	102.1	72.2	47.1	44.2
Painters	47.4	92.8	95.9	45.6	44.1
Plasterers	67.7	107.2	58.3	44.6	40.9
Plumbers	61.6	101.3	64.4	45.4	43.8
Sheet-metal workers	51.8	99.7	92.5	45.5	44.0
Steam fitters	61.2	95.0	55.2	45.5	44.0
Structural-iron workers	62.1	116.7	87.9	44.5	44.0
Inside wiremen	52.8	95.9	81.6	45.6	44.0
Unskilled labor	30.0	65.0	116.0	48.4	45.2

This table shows considerable variation in the increases obtained by the different skilled trades, between 1914 and 1920, the variation being from 55 per cent in the case of steam fitters to 96 per cent in the case of carpenters. The average increase may be taken as falling between 70 and 80 per cent. In the case of unskilled labor the wage increases were considerably higher, averaging slightly over 100 per cent.

Who Cleans Brick

Information collected by the Associated General Contractors of America with a view to deciding a jurisdictional question regarding the cleaning of brick indicates that the cleaning of old brick is always done by laborers, while the cleaning of brick walls is done by bricklayers or laborers. Replies from 26 cities are tabulated below:

City.	Cleaning walls done by	Cleaning old brick done by
Baltimore	Bricklayers	Laborers
Birmingham	Laborers (no pointing)	Laborers
Boise	?	Laborers
Boston	Bricklayers	Laborers
Chicago	?	Laborers
Cincinnati	Bricklayers (often by laborers)	Laborers
Cleveland	Bricklayers	Laborers
Dallas	Bricklayers	Laborers
Des Moines	Bricklayers	Laborers
Detroit	Laborers unless sublet to "tuck pointers"	Laborers
Kansas City	Bricklayers and non-union "cleaners"	Laborers
Los Angeles	Laborers	Laborers
Louisville	?	Laborers
Milwaukee	?	Laborers
Nashville	?	Laborers
New Orleans	Bricklayers and special laborers	Laborers
Philadelphia	?	Laborers
Richmond	?	Laborers
San Antonio	?	Laborers
San Francisco	?	Laborers
Savannah	?	Laborers
South Bend	?	Laborers
St. Joseph	?	Laborers
St. Louis	?	Laborers
Tacoma	Laborers	Laborers
Toledo	[illegible] and laborers	Laborers

Colorless Waterproofing Materials for Building Stones.—The exposure tests on sandstone and limestone now being conducted by the U. S. Bureau of Standards, after a 4-month period, indicate that several proprietary materials are effective in reducing the absorption of moisture by the stone to 5 per cent or less than that of the untreated specimens. However, all of the exposure specimens continue to indicate a slight increase of absorption as the test progresses.

Fabricating Shop Contracts in March.—The records of the Bridge Builders and Structural Society, from reports collected by its secretary, show that during the month of March, 1921, 52,300 tons of fabricated structural steel were contracted for throughout the United States, equivalent to 29 per cent of the entire capacity of the bridge and structural shops of the country.

Design Features of Bridges for New Jersey Highways*

By CHARLES DEEMS,
Bridge Engineer, New Jersey State Highway Commission

The state owns at present 704.2 miles of highways on which exist 568 bridges of over 5 ft. span. They comprise timber, masonry and metal structures of various kinds, lacking in uniformity of specification and condition, but all of which are called upon to support the traffic which the development of the internal combustion engine has thrust upon them.

The number of miles of road per bridge varies considerably —from 0.5 on Route 16 to 8.1 on Route 14. Roughly, 60 per cent lie in the northern part, 29 per cent in the central part and but 11 per cent in the southern part of the state.

80 Per Cent of Existing Bridges Cannot Meet Modern Traffic Demands.—It is not the intention of this paper to criticise the design of a generation ago when a farm wagon or a load of hay was considered a heavy load. That bridges which were well designed for the loading of what may be expected of those now building, for a well designed bridge will carry a large percentage of occasional overload without distress. Today, however, 80 per cent of the existing bridges in this state are incapable of meeting the demands of modern traffic.

When the state assumed control of the highway system last year several very important bridges were on the verge of failure, two of the more recently constructed ones had actually collapsed and others needed immediate attention in various ways to keep them in service until major repairs or rebuilding could be reached. This repair work has proceeded along with the preparation of plans for the new structures designed for modern loading.

20-Ton Loading for Bridges.—After a careful study of the various truck loadings actually in service and the tendencies of the times both from a military and commercial point of view, a loading was adopted, commonly referred to as a 20-ton truck, which would produce bridges adequate for the demands of modern traffic and provide for such increases as are sure to come. The loading, therefore, is not so much a typical truck as a live loading which will produce serviceable bridges.

The geographical location of New Jersey between the two great commonwealths of New York and Pennsylvania makes it imperative that her structures should be of the best. Restrictive legislation to be permanent must be in accord with the demands of commerce. Growth far beyond the vision of traffic experts in every other mode of transportation has been experienced, and highways will prove no exception to the rule.

Types of Bridges.—Deck bridges, being the most economical in first cost and maintenance, are to be preferred wherever the conditions are favorable. Long spans and low head room often compel the use of through or half through bridges. Of these the most economical is the plate girder. Beyond the limits for plate girders the more elaborate lattice girders must be used, giving preference in all cases to riveted over pin connections because of the greater rigidity possible. For spans up to 20 ft. reinforced concrete slabs are to be preferred. Encased I-beams may be used up to 30 ft. Beyond that, built-up sections must be resorted to. Transportation limitations must be considered as a material factor in design.

Concrete, being a durable structural material of low cost and diversified application, finds almost universal use in the modern bridge. Used in mass work for substructure and in combination with reinforcing steel for superstructure parts subject to transverse bending, it forms an ideal material for permanent structures. Even though its properties are so universally known and appreciated, it requires careful and honest workmanship and good design to produce enduring results.

Water-Pumping Structures.—Owing to the difficulty of making concrete entirely water-tight, and as water is almost a universal solvent, it is of the utmost importance that the entrance of water to any part of the structure be prevented. This is especially true of parts not accessible for inspection. Paint on metal work is effective on parts exposed to air which aids in the rapid removal of moisture.

Structures should be so designed that all possible parts can be inspected. In the case of inaccessible parts, such as imbedded steel, if reached by moisture, changes will occur and may progress with surprising rapidity, especially if electrolytic action is present. Where there is no actual leaking, the presence of water will be indicated by surface staining, indication of leaching and spalling most strongly marked at joints or pour lines.

The formation of rust scale on embedded steel sets up great pressure, recorded as high as 4,700 lb. per square inch, which will destroy the bond and eventually menace the safety of the structure. Water should, therefore, be conducted away from the bridge as rapidly as possible by providing drainage grades in every part. Inaccessible parts should be protected by waterproofing, which is cheap insurance. With waterproofing cost at 2 per cent of the cost of the structure and money at 4 per cent it is evident that if waterproofing prolongs the life of the bridge six months it pays to do it.

Construction of Floors.—Because of under-clearances and the reduction of dead load, it is generally desirable to produce the thinnest floor consistent with good design. This can be accomplished by carrying the live load directly on the floor slab after providing a small extra thickness of concrete cast integrally with the slab for wearing surface. Otherwise, to protect the slab from wear, the entire surface may be covered with some bituminous compound applied in a plastice condition or with paving blocks of wood or other material. The latter makes a slightly thicker floor than the former

The width adopted is 30 ft. between curbs for all new bridges; and sidewalks are to be provided where required.

The distribution of load concentrations on slabs is a subject which is being intensively studied from the meager data resulting from destructive tests. The tendency is to slightly reduce the slab thickness from the old assumptions of distribution wherein the load was distributed at 45 degrees in each direction to the plane of reinforcement, resulting in a somewhat lighter and cheaper bridge. Further tests are needed, however, in order to fully cover this subject.

Where floor thickness is not a material factor, conditions more nearly approaching ideal may be realized in small spans by locating the slab low enough to permit the road construction to be carried continuously over the bridge. In any case, the road paving on the bridge should extend continuously from curb to curb.

Slab floor bridges of short spans on solid supports will usually be found stiff enough to provide for lateral, longitudinal and centrifugal forces. The necessity for adequate bracing in all directions should never be lost sight of, to the end that the resulting structure be rigid under all conditions. Unless a bridge can be used as unrestrictedly as the highway it connects, it is not an adequate bridge.

Bridge Railings.—Bridge railings, to afford necessary protection, should be designed to be capable of withstanding the impact from unmanageable vehicles of the weights specified. A monolithic concrete railing well reinforced will be found adequate. Such a railing is not an extravagance, as it can be produced at a cost about equal to a heavy galvanized pipe railing and is vastly superior to it in strength, endurance and appearance. It is the practice to mold the state's name, route number, and year of erection in these railings.

The only impression gained of a bridge by the traveling public is that attained by the appearance of the railings. These should leave in the mind the pleasant sensations of safety and harmony.

There seems to be a widespread notion that arches are beautiful. Some are. Being predicated on immovable abutments they should never be used in flat marshy country where there is the slightest question of security concerning the foundation material. Simple spans giving vertical reactions can be made attractive in appearance and when they are in harmony with their surroundings and express a structural necessity they are pleasing.

Good design requires an arrangement or grouping of parts so that the eye is led to consider the structure as a whole rather than an accumulation of unrelated pieces which lack interest because of their incongruity. It need not cost any more to produce structures which are pleasing to the eye than those which are displeasing. The matter of aesthetics is, therefore, of great importance.

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*Abstract of a paper presented Jan. 25 at the annual meeting of the New Jersey State Association of County Engineers.

Methods of Supporting Concrete Chute

By J. H. WILLIAMS.

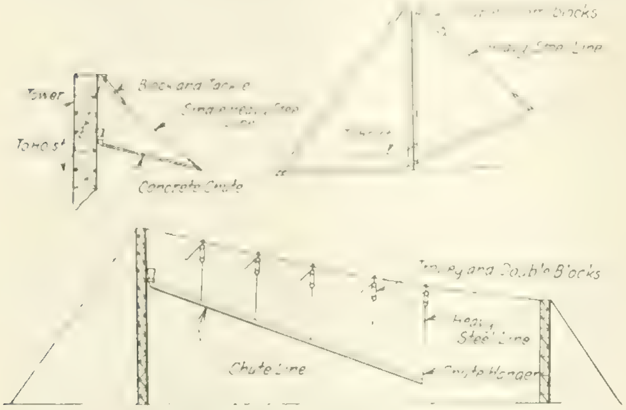
Of The Lakewood [illegible]

The attached sketches show a [illegible] although not new in any sense of the word, [illegible] often as it could be. In each case it effects somewhat of a saving in steel line.

On the boom line for a concrete chuting plant it is not necessary to rig the steel blocks and line for the full length inasmuch as the travel of the boom is very limited and only a few feet of such travel is required. Therefore, a heavy piece of steel line can be attached to the bale at the end of the chute and carried up to the steel block. On a 50-ft. boom chute this line can be at least 30-ft., which will effect a saving of 120 ft. (of four part line).

On a concrete chute line where there is considerable distance between the chute and the chute support line this same scheme can be effected, as shown in the sketch. Very often a derrick can be rigged the same way, provided it is not necessary to have much travel distance up or down for the boom

Of course these suggestions will not always be satisfactory, but there are a number of places where they can be used and they are well worth remembering. In most cases it is not necessary to purchase new line for this purpose as there is usually on all jobs discarded line that has sufficient strength for this purpose. Particularly is this so as shown on the sketch covering the continuous line chute support in this manner.



Sketches Showing Method of Supporting Concrete Chute.

Channels and Crimped Furring

The Milwaukee Corrugating Co., Milwaukee, Wis., is now manufacturing a new pressed steel channel for use in building work. The channels are cold rolled, and present a level surface on all three sides. They are accurately pressed at perfect right angles and are uniform and straight throughout their entire length. The stock sizes and weights of these channels are: ¾ in., 0.276 lb. per lineal foot; 1 in, 0.332 lb.; 1½ in., 0.442 lb. The leg is ⅜ in. long. The stock lengths are 12, 14, 16, 18 and 24 ft. The same company also has brought out a crimped furring made from No. 22 band iron. This is being manufactured in the following sizes: ½ in., 20 lin. ft. to 1 lb.; ¾ in., 15 lin. ft. to 1 lb.; 1 in., 10 lin. ft. to 1 lb.

Effect of Sun's Rays on Temperature of Steel.—Investigations made at Balboa Heights, Panama, Canal Zone, by the U. S. Weather Service, to determine the maximum temperatures of steel exposed to the direct rays of the sun are described in the Monthly Weather Review. The tests were made on steel blocks measuring 2 in. by 12 in., laid on boards on a concrete pavement and sheltered from the wind. The thermometers were immersed in mercury-filled holes in the centers of the blocks. The highest temperature recorded was 133° F., measured at 3:30 p m. towards the end of April. It is thus suggested that the maximum temperature of steel exposed in that locality is not likely to exceed 140° F. Comparing the climatic conditions with those of various parts of the United States, the investigator estimates that the maximum exposed steel temperatures in the deserts of the Southwest my reach 169° F. or higher. That very noticeable effects are produced by the expansion caused by one-sided heating, has been observed in the case of the steel spillway gates of the Panama Canal, the leakage through which is greater in the day time than at night, on account of the action of the sun shining on one side and causing the gates to buckle or warp slightly. Another set of measurements was made to compare the heating of blocks of steel painted with different colors. At the maximum, from 12 to about 2:30 p. m., with the air temperature in the shade about 88° F., the temperatures of white, red, green and black blocks, respectively, were 112, 114, 123, and 128°.

Zoning Survey at St. Paul, Minn.—The City Planning Board of St. Paul, Minn., of which Geo. H. Herrold is managing director and engineer, is now making a zoning survey and it is believed that a zoning ordinance will be ready to be submitted to the City Council this fall. The survey is being carried on by the local engineering office of the St. Paul City Planning Board. Bennett & Parsons, City Planners, have been retained as consultants in the preparation of the ordinance.

Personals

George L. Stanley has been appointed city engineer of Burlington, Vt.

N. A. Kemmish, a civil engineer of York, Neb., has assumed his duties as city manager of Alliance, Neb.

Berry E. Brevik has resigned as chief draftsman of Spokane County, Washington, and has purchased an interest in the Glasser Construction Co., 327 Hutton Bldg., Spokane, Wash., of which firm he will be engineer.

Victor T. Goggin, heretofore New England sales manager of Fred T. Ley & Co., Inc., of Springfield, Boston and New York, has severed his connection with that concern to associate himself as contracting engineer with Dwight P. Robinson & Co., Inc., of New York, Chicago, Dallas Youngstown, Los Angeles and Montreal.

Frank White, who has been named for treasurer of the United States, is a graduate of the civil engineering department of the University of Illinois. He went to North Dakota in 1882 and settled as a farmer. He was elected governor in 1900 and served four years and has since engaged in business.

Athol B. Edwards of New York City has been appointed city manager of St. Albans, Vt. He was employed under Chief Engineer F. L. Thompson of the Illinois Central R. R. in the construction and maintenance departments from 1901 to 1917; afterwards for a year with the Massey Concrete Products Corporation of New York, and later with MacArthur Brothers Co., contractors and engineers.

Obituaries

Ralph J. Burley, assistant director and chief engineer of the Reclamation Service in the Department of the Interior, Ottawa, died April 14.

Charles E. Becker, a road contractor, was killed April 20 when an automobile in which he was riding was struck by a Lake Erie & Western train at a grade crossing six miles north of Plymouth, Ind.

Lester Gray French, editor of The Mechanical Engineer, died April 18 in a hospital in New York City, following an operation. He was author of a number of books on mechanical engineering subjects, including the earliest American treatise on the steam turbine. Mr. French was born in Keene, N. H., in 1869, and was educated at the Massachusetts Institute of Technology.

Henry W. Kolkmeyer, a contractor, died April 20 at his home in Jefferson City, Mo., aged 83. In the early days of railroad building he held contracts for construction of the Missouri Pacific and other Missouri railroads and later handled railroad contracts in southern Missouri and northern Arkansas. He was one of the contractors engaged in the construction of the governor's mansion and many of the older substantial buildings in Jefferson City.

Industrial Notes

O. L. Moore, chief cement inspector, Universal Portland Cement Co., has been appointed engineer inspection bureau with headquarters at Chicago, to have charge of all matters pertaining to cement inspection.

Yeomans Brothers Co. of Chicago have announced a decided reduction in the prices of their products, which include the Shone pneumatic sewage ejector, electrically operated centrifugal sewage ejectors, automatic electric bilge pumps, condensation return pumps and horizontal centrifugal pumps for all purposes.

H. M. Davison, who from 1903 to 1919 was with the Hayward Co., manufacturers of orange peel, clamshell, electric motor clamshell and drag scraper buckets and for two years just past was general sales manager for Ohio Locomotive Crane Co., has again become associated with the Hayward Co. and will hereafter be connected with the management of that company. Among other duties he will have the general management of sales.

The Link-Belt Co., of Chicago, Philadelphia and Indianapolis, have just sent broadcast the following letter to the trade: "The shrinkage in business has given us an opportunity to restore the economies in manufacture that had to be sacrificed during the high pressure of the past three years. Our overhead expenses have been reduced, the efficiency and output of our men have been increased, our raw materials have been marked down to the present market. All of the reductions in cost effected through these steps, together with a considerable portion of our profits, have been applied to price reductions. This general price reduction applies to our complete lines of elevating and conveying machinery, our malleable iron and "SS" class steel chains, malleable iron buckets and sprocket wheels."

Roads and Streets Monthly Issue

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Roads and Streets—1st Wednesday

(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday

(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday

(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday

(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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To Our Readers

Circumstances beyond our control make this issue late in reaching you. Last Monday, the day Engineering and Contracting is printed, a strike occurred in all the union book and job printing shops in Chicago, and in many other cities. The trouble arose over the placing in operation of a 44-hour work week. The unions contended that there should be no reduction in pay; that the men should get the same wage for 44 hours as they had been receiving for the previous work week of 48 hours. The employers insisted that if the men worked 44 hours they should be paid only for that time. As a result of the dispute all work in print shops stopped. It is not our intention to comment on the rights and wrongs of the situation. We merely give a plain statement of the facts so that our readers may know why this paper failed to reach them on time. On Thursday the employers and unions reached an agreement, under which the men get their 44 hours, but with a reduction in pay. The same day the printers resumed work and thus enabled us to get out this issue only a few days behind its scheduled time.

Street Names

Originality and appropriateness are virtues too often overlooked in the naming of our new streets. Most frequently and conspicuously are they lacking in the plats of new "additions"—less frequently, but still too often, in the plans of new townsites. The editors of Engineering and Contracting are not haters of the English and their institutions—in fact they admit a pride in their English blood, and an ardent admiration for England's countless gifts to society. But they do not see any valid reason for the common attempt to make an American street directory read like a section of London.

"Margate Terrace," "Hampden Court," "Nottingham Road," "Stratford Avenue," are among the designations against which protest is made. "Regent Street"—the commonest offender of all—may be fitting near a university, but elsewhere in America regents are rather out of fashion. Not only are these inappropriate, but such names have been used so often that many American districts seem simply to be imitating one another.

Nor is our surrender of originality and appropriateness made to England alone. To a lesser extent we have capitulated to almost every country; and if possible, with less reason than to England. We have also unblushingly copied from sister cities of our own country. Why should "Broadway" be scattered over forty-eight states—especially in cases where it has no particular claim to such a title?

"Main Street" lacks originality but is at least generally appropriate where used. "State Street" is old but it has a dignified fitness when applied to the most important thoroughfare of a town.

The lack of valid reason does not mean the absence of motive in the bestowal of these nomenclatures. English names are copied because they are suggestive of pleasantness, affluence, and social standing. The real estate promoter thinks they will attract buyers. "Broadway" suggests hustle and the center of business: hence the ambitious young municipality wants its "Broadway." Hence also, energetic business men on Evanston avenue, Chicago; on South "C" street, Tacoma; and in other similar situations get Broadway as a substitute for the old name regardless of fitness. We doubt very much if in any of these cases the name adds an appreciable commercial value; but if it does so, it must be at the expense of other streets, and there would be just ground for complaint by the business on other streets, that established municipal conditions were being changed to the advantage of their competitors.

What factors should control the selection of names? Local significance seems a prime one. It is fitting that the founders of a community should be memorialized in the streets over which their successors pass. It is also fitting that roads should retain the names which indicate their destinations. A bridge, a mill, a forest, a farm may give reasonable foundation for a name, but in a growing [illegible] worthy local names are likely soon to be exhausted. We then generally fall back on some system such as the [illegible] of the presidents or the states of the Union. Such systems, if lacking novelty, at least fit their national environment; and it is to be regretted that they are frequently broken up to such an extent as to lose much of their significance.

Systematic naming is desirable because it adds to convenience; and there is no dearth of systems or groups of names which might be so used. In addition to the presidents we have a worthy list of American statesmen, and another of men of letters. Soldiers, scientists, philanthropists, great men of any class furnish possibilities. Nor need we exclude foreigners whose works are of world-wide value.

A group of great men from different nations may afford an excellent system, whereas an isolated foreign name may be incongruous and objectionable. But human names furnish only a small part of those possible: there are the planets, the stars, the constellations, the trees, the flowers, precious stones, the minerals, states, counties of the home state, cities, the books of the Bible, and as many more as one will take time to think of. Some of these systems are in occasional use at present. Few of them possess any special appropriateness but they do avoid tiresome imitation, and they do not involve fulsome tribute to human vanities.

Numbered streets afford so much convenience that they will probably continue to be used. Their unattractiveness is counterbalanced by their practicality. Lettered streets are also convenient but they have never proved popular, and have sometimes been changed one by one until the gaps in the system spoiled its usefulness.

Simple alphabetical arrangements are quite common, and names having arrangements of letters and syllables which indicate their location are not unknown. They are quite convenient, although the elaborate names without significance except as to locality are hardly pleasing in their suggestion. A system of this sort is "Alderdale," "Briardale," "Cherrydale," "Devondale," etc., for one section of a town, and "Altemont," "Belmont," "Cremont," "Darmont," etc., for another section.

Truly it takes little ingenuity to avoid hackneyed street names. To acquire appropriate names is more difficult but usually is possible. Lack of both originality and appropriateness is unpardonable.

The Importance of an Office Library

It is the least studious engineer who must look up the most references whenever he steps from his own familiar fields; and however invaluable his handbooks, they cannot be all sufficient on a major problem. His handicap in the absence or inaccessibility of a library needs no comment. To his more studious brother the want of a library is a calamity. Yet how many engineers are continually meeting this condition!

If engineering offices maintained engineering libraries they would have better engineering; and this is true even of offices located in cities where good public libraries are available, for convenience of access means more frequent and more efficient reference.

Furthermore, the best of the younger employes will find in the presence of a library, a measure of inspiration and inducement to study which will react to the advantage of the employers, and very greatly to the advantage of the men themselves.

In state, county and city offices, where change of personnel is all too frequent, it is particularly desirable that the office have its own library. One chief engineer may be well equipped with books—his successor may be nearly without them, and work may suffer accordingly. The office library will naturally be more extensive than that of the individual engineer; and it possesses the very great advantage of being provided to meet the particular needs of the particular office. However many books the new incumbent may have, there is small chance that they will comprise the best collection for the specific case; and where tenure of office is uncertain and salaries are small, the engineer can scarcely be blamed for some reluctance in spending his own money for books on problems with which he may not long have to deal.

Where the individual office library can not be, or is not to be had, a supplying of the deficiency by other means should be sought. If local public libraries are not available, or are inadequate, the traveling state library is a most useful institution. An extended use of certain stationary libraries is suggested by Mr. A. E. Foreman, chief engineer, Department of Public Works of British Columbia, in an article entitled "Organizing Provincial Highways Departments" in a past issue of "The Canadian Engineer." Mr. Foreman says: "Engineers should undoubtedly be provided with the best and latest literature on road work. Arrangements should be made with provincial libraries whereby standard technical books might be loaned to any of the district and assistant engineers when required in connection with any special work they were doing. They should also be placed on the mailing list for such publications as those issued by the Bureau of Public Roads of the U. S. Department of Agriculture and similar bulletins; and special articles in mechanical journals should be called to their attention, or copies supplied to them."

While the desirability of the private technical library is by no means to be minimized, the office library can be made to serve a larger purpose not merely by reaching more people, but by its greater extent and the fact that it can have certain books which the individual may feel that he cannot afford to buy.

Excessive Fees Paid to Appraisal "Experts" by Chicago

A suit to force the return of more than $1,000,000 paid by the city of Chicago to appraisal experts, and to prevent the payment of a similar amount classed as earned, was started on April 19 by the Chicago Tribune as a taxpayer of the city. The Tribune's bill alleges that there is a conspiracy to cheat and defraud the city, and that the larger part of the $1,000,000 paid last year was from an appropriation which was null and void for the purpose of paying such experts. The daily's own statement of its five main objects in bringing the suit is:

1. Repayment of more than $1,000,000 paid these experts for last year's services.
2. Repayment in full of all sums subsequently paid them.
3. The prevention of the payment of any more money to them.
4. The names of the conspirators and their method of operation.
5. The names of persons to whom Mesce and Lynch are alleged to have paid money.

Prior to the bringing of the suit, the Tribune and other Chicago papers had published numerous articles on the subject of the expert fees and their apparently excessive amounts. The editor of Engineering and Contracting combines the published data on these expert fees and the property values on which they were incurred (all of which are to the best of his belief undisputed) with his own knowledge of valuation matters, and concludes that the newspapers have failed to show the full extent of the overcharge.

About 5,200 buildings, totaling about $72,000,000, have been "condemned" in Chicago in order to widen certain streets. The two political "expert" appraisers who are appraising these buildings have already been paid $1,000,000 for their services, while $1,200,000 more is credited to them as earned and $660,000 is scheduled to be earned, a total equivalent to 4 per cent of the value of the buildings, each "expert" receiving 2 per cent of the value as his compensation!

In defense of this squandering of public money, President Michael J. Faherty of the city board of local improvements has said that by "a rule of the American Institute of Architects" the fee for such appraisal work would be more than 8 per cent, therefore Chicago is getting this appraisal at half price! There is no rule of the American Institute of Architects, or of any other organization of builders, prescribing fees for appraisal services. Evidently President Faherty has in mind a fee for designing and superintending the construction of a building, which is quite a different matter.

Fees for appraising buildings may occasionally be based upon the values of the buildings. Very frequently they can be estimated as approximate percentages of value. For example the published and authorized rates of the Cook County Real Estate Board show that for appraisals like those for which Chicago has paid four per cent their charge would be about one quarter of one per cent. The corresponding rates of the Chicago Real Estate Board indicate a charge of about four tenths of one per cent for the same work.

"But," President Faherty would reply, "those fees do not include making drawings of the buildings and the city's 'experts' must make drawings in order to get their 2 per cent fee." This has a plausible sound until we read that the city has agreed to pay to each of the "experts" 1¼ per cent for an appraisal without drawings, or 2 per cent with drawings, making the fee for drawings ¾ per cent. The daily newspapers of Chicago have added the ¾ per cent to the 0.4 per cent to arrive at a maximum reasonable charge for this appraisal work, but the newspapers have been altogether too liberal, for the charge of ¾ per cent for appraisal drawings is itself as outrageously high as the charge of 1¼ per cent for the bare appraisal. Moreover, why in the name of common sense should each of the two "experts" prepare separate drawings, when one set of drawings would suffice?

The editor intends sending this article to Chicago newspapers and therefore may, perhaps, be pardoned for stating some of his own qualifications for passing judgment on the fees charged by the city appraisal "experts." As chief engineer of the Washington Railroad Commission the editor had charge of appraisals totaling $225,000,000. As appraisal engineer for many different companies and individuals, he has placed values on other properties totaling about $500,000,000. Fifteen per cent of this total was real estate. In all this appraisal work the highest cost of the appraisal for any group of buildings was ½ of one per cent of the value thereof This is in accord with the testimony of H. B. Wheelock, of the American Institute of Architects, who testified before a committee of the Chicago city council, that on the appraisal of a group of forty buildings totalling between $2,000,000 and $2,500,000 for the Northwestern railroad, the highest fee paid to any one of the six appraisers engaged was considerably less than one half of one per cent.

In a careful quantity survey of a building, only the roughest of sketches are need (nothing comparable with an architect's finished drawings), and the cost of such sketches is included in the ½ of one per cent cost of the appraisal. The quantity survey is, by all odds, the most expensive part of a building appraisal, but one quantity survey will suffice for any number of independent appraisers. Appraisers rarely differ materially as to the quantities in a building; their differences, if any, arise over the unit prices and the extent of the depreciation. Hence two independent appraisers, by using the same quantity survey, should appraise a group of buildings at not to exceed 0.6 per cent of the value assigned to them. At this rate, the appraisal of the $72,000,000 worth of buildings under discussion, should have cost the city of Chicago not to exceed $430,000, instead of $2,876,000. In other words, the city of Chicago is paying seven times as much for this appraisal of buildings as it need have cost if made by any two of the most competent appraisal engineers in America.

If the citizens of Chicago wish to verify this estimate, the means of doing so are at hand, for the Interstate Commerce Commission is making a valuation of all the property of the steam railways in this section of America. The cost of appraising buildings owned by these railways in Chicago and nearby towns may be safely taken as a standard by which to judge what is a reasonable cost for such appraisals in Chicago. The editor has no knowledge as to what this appraisal work has cost, but he is certain, based on his own experience, and that of many other engineers, that it has not exceeded one half of one per cent.

In addition to the 4 per cent that the city of Chicago is paying the two "experts" for appraising the 5,200 Buildings, the city is paying three land "experts" one per cent each (a total of 3 per cent) for appraising the land! The value of the land is about $67,000,000, or equal to the value of the buildings; and a liberal cost of appraising it would be about 0.3 of one per cent, to be divided among the three land "experts," which is one tenth of what it is costing the city. Here, again, the editor's estimate can be verified by ascertaining what it has cost the government to appraise railway lands in Chicago.

In estimating appraisal costs as percentages of property value, it should be remembered that construction costs have increased to a greater degree than have the fees and salaries of appraisal experts and their employes. Hence a percentage cost for appraisal work is usually less today than it was before the world war for corresponding work.

Popularizing Science

In recent years the demand on the part of the public for information of a popular character concerning the progress of science has been continually increasing. This demand has even been appreciated by the various government research bureaus, and efforts have been made to popularize their publications, but thus far with indifferent success. The concise detailed form of the government scientific report has become almost unintelligible to many of the people whom it was intended to assist.

Although, to some extent, research work for the sake of the discovery of new facts with no regard to their application is subsidized by the government, the major part of the work is supported because of its practical utility. There is, consequently, an obligation resting upon the workers to have their contributions expressed in the most readable form, although it must be admitted that such obligations are not always accorded due consideration. Little progress has thus far been made in popularizing the government scientific publications, and quotations of abstruse technical verbiage, meaningless to the ordinary person, are often made in periodicals for the purpose of ridiculing government research work.

When the scientific investigator has endeavored to write for the layman he has frequently found it difficult to express his ideas accurately without the use of his technical vocabulary, and the defining of all the technical terms has often so seriously encumbered his article as to make it uninteresting to the casual reader. When the "hack writer," after reading a few articles or interviewing some prominent research worker, has tried to inform the public of the new and startling discoveries of science, the results in many cases have been ludicrous. Non-important matters have been mistaken for important ones, facts and theories have been confused, gross exaggerations, due to the too vivid imagination of the writer, and a general lack of proper discrimination have been the rule rather than the exception. Articles by the non-scientific writer are not all bad, and many of the popular descriptions of new researches in the supplements of our Sunday newspapers are of great value, but too frequently they are so misleading as to embarrass the scientific investigator and to seriously discredit him among his fellow workers.

Notwithstanding these difficulties, it is generally recognized that some way must be devised by which the intelligent reading public may become acquainted with the new developments of science. Apparently this must be done by means of articles written as far as possible in non-technical language. If in addition this can be done by the usage of a distinctly literary style, the results will be far-reaching in their effects. It may well be that the time will soon arrive when research workers will be made to feel that the acquisition of a simple readable style is as important as the ability to conduct research for the purpose of adding to the sum of human knowledge. At least it is to be hoped that some of the most glaring defects of present day scientific contributions may be overcome.

An interesting example of the work of a distinctly literary man in the field of science is afforded by H. G. Wells in his recently published "Outline of History," in which there is a resume of the entire field of Historical Geology. In the preface the writer states that "his disqualifications are manifest," but adds that every chapter in the work has been revised by a "more competent person than himself," and whom he seems to have regarded as properly qualified for the task.

Notwithstanding the fact that the work bears evidence of considerable preparation by extensive reading, and that the style is far superior to that of our ordinary books on geology, the result is far from satisfactory, and seems to show the necessity of having our geological literature popularized by geologists rather than by literary people who seek to inform themselves by a short course of intensive reading. The literature of geology is too vast to permit one to master it sufficiently to write such a review as Mr. Wells has prepared without the expenditure of far more time than he evidently had at his disposal.

Admittedly, when an author reviews the history of the world from the beginning of geologic time to the present in two 600-page octavo volumes he is to be excused for dogmatic assertions and the failure to include many of the numerous theories of science, but it is unfortunate when preference is given to discredited or at least unsatisfactory theories. The observant reader must be surprised to learn in Mr. Wells' work that the nebular hypothesis is accepted without question as the correct explanation of the origin of our solar system, that Eozoon Canadense is nothing more than a crystalline marking"; and that the Pleistocene Ice-Age was brought about by the greater ellipticity of the earth's orbit, the change in the obliquity of the equator to the orbit, and the precession of the equinoxes. Other errors have crept in, despite the critical reading of his scientific friends. Nevertheless, we commend Mr. Wells for his courage in undertaking such a monumental task, but in regard to the facts of geologic history we are still waiting for the accurate and popular literary account.—Editorial in the Engineering and Mining Journal.

The Engineer In Public Service

"If the engineer has not been appreciated as much as some other classes of men it is because his service to humanity has not been the highest," said Dexter S. Kimball recently in the course of a speech before the student members of the American Society of Mechanical Engineers. He went on to say that the men who render the greatest service to any nation are those who mold its ideals, and that engineers must do something in this line before they can achieve real public recognition. "I have every confidence," he concluded, "that the engineer will rise to this opportunity, and there are many signs that these ideals are stirring in the minds of forward-looking engineers. It is with no small gratification that we all see the elevation of our past-president, James Hartness, to the gubernatorial chair of his own state, and see Mr. Hoover, an engineer by training and experience, a member of the cabinet of the new administration. These are pioneer workers in a field where the lawyer and the politician have long reigned supreme, and their stewardship will be watched by all engineers and others with great interest. It is an auspicious beginning that should hearten all who believe in the application of scientific methods to all problems of human existence."

Much has been said and more has been written lately about the need of public appreciation of engineers, but the public as a whole is never greatly impressed by arguments. The entrance into the limelight of Herbert Hoover and James Hartness is just what is needed to start the ball rolling and to secure general recognition for the engineering profession. It should serve also as an inspiration to other engineers whose modesty, perhaps, has been holding them back.—Editorial in Power.

Municipal Camps in National Forest Parks.—Free permits for eight municipal recreation camps in the national forests of California have been issued by the Forest Service of the United States Department of Agriculture. This state is taking the lead in establishing these camps, where the residents of the cities which maintain the camp may obtain a summer outing at cost. Last year four such camps were operated in the California national forests—two by the city of Los Angeles and one each by Sacramento and Oakland. These four represent an investment of $70,000, and nearly 5,000 guests were accommodated. This year Los Angeles will have a third camp in operation, and San Diego and Fresno and Riverside Counties expect to open camps also. In addition to its camps, the Los Angeles Playground Department organizes and supervises 2-week hiking outings in the Angeles Forest. Three of the eight camps are in the Angels, two in the Cleveland, and one each in the Sierra, Stanislaus, and Eldorado National Forests. The camps are from 25 to 150 miles from the municipalities that maintain them. Only residents or taxpayers of the municipalities that operate the camps are eligible as guests, and, because of the low cost of the outing, each camper is required to render on an average one hour's daily service as outlined by the director in charge, and must also furnish his own bedding. Guests are well housed, fed, and entertained. The following rates for a 2-week outing, including transportation, were in effect last year:

[illegible]	City	[illegible]	[illegible]	Cost.
[illegible]ngeles	Los Angeles	Seeley	75	$12.75
[illegible]	Los Angeles	[illegible]	[illegible]	[illegible]
[illegible]	Oakland	[illegible]	[illegible]	[illegible]
[illegible]	Sacramento	[illegible]	[illegible]	[illegible]

These rates were all for adults, and the rates for children under 10 were from 50 to 60 per cent of the above.

Resurfacing Concrete Pavement with Thin Reinforced Concrete Slab

Resurfacing a worn-out concrete pavement with a thin concrete slab instead of the usual topping of bituminous material has been approved for Idaho Federal aid project No. 49, which comprises 1.54 miles of the Idaho-Pacific highway on the outskirts of Boise, Idaho. This section of roadway was paved in 1912 with one course of 6-in. concrete, rather poorly laid, which under the heavy traffic imposed upon it has gone to pieces in many places, and so many cracks and potholes have developed that some method of reconstruction has become imperative. Traffic on this section amounts to about 2,800 vehicles daily, of which 250 are motor trucks. The old pavement was laid 16 ft. wide, and in view of the heavy traffic above noted, this width has become manifestly inadequate, and any improvement must involve the widening of the pavement to a standard double-track width of 18 ft. How this work is to be handled is described by Mr. T. M. Keene, district engineer, U. S. Bureau of Public Roads, in the April issue of Public Roads.

Since the original intention was to retop this pavement with a bituminous mix, bids were asked for on a top of this type as well as on a concrete slab, but resulting prices were so greatly in favor of the latter construction that in spite of its comparative novelty its use was recommended and approved. Bids were respectively $2.10 per square yard for a 2-in. bituminous concrete top, and $1.30 per square yard for a 3-in. cement concrete slab.

Construction of the concrete slab topping will involve, first, the placing of an extra strip of concrete 2 ft. in width on each side and to the full depth of the old pavement. These strips will consist of a 1:2:4 mix, struck off even with the old surface. At the same time the old slab itself will be cleaned and all depressions filled with the same mix and struck off so that a base slab 18 ft. wide with a uniform surface shall be obtained. The new concrete is to be thoroughly cured before placing the top slab.

While the use of a bituminous top requires as close a bond as possible between the top and the concrete base, a topping of cement concrete calls for a method which will result in an entire absence of bond between the top and base. The extent of contraction and expansion in the two courses would vary considerably and bonding the two together would doubtless increase the tendency to crack, whereas a complete separation of the two slabs will permit of a slight movement in each slab independent of the other. Therefore, after the new portions of the reconstructed base are sufficiently hardened the surface is to be thoroughly cleaned and sprinkled with a light uniform coating of hot Tarvia. There will then be placed on the Tarvia-coated base a layer of concrete of a 1:2:3 mix 1½ in. in depth. On this layer is to be placed a reinforcing fabric consisting of a flat steel wire mesh weighing not less than 28 lb. per 100 sq. ft., and additional concrete is to be immediately deposited to secure a completed thickness of 3 in.

Since the old pavement had expansion joints at 30-ft. intervals, similar joints are to be placed in the concrete topping at the same points, although it is planned to break joints in a few instances as an experiment to determine the comparative value of such spacing for future work.

The adoption of a concrete slab topping might be inadvisable in places where grades are fixed within very narrow limits, as, for instance, on curbed streets; also, on account of the length of time that the road must be closed to traffic, this construction might be objectionable where no suitable detours are available. In general, however, it would appear that this method should be given careful consideration as affording a competitive type of resurfacing for concrete roads, which, even if not adopted, would tend to reduce bids on other types with consequent ultimate economy.

The experience of the board of county commissioners of Wayne County, Michigan, has been of value in forming recommendations in regard to this somewhat unusual method of resurfacing.

Road Grading with Tractor Drawn Wheel Scraper Outfits

By W. B. HILL, JR.

In grading the Dixon-Henderson road in Webster County, Kentucky, Mr. Mitchell of Townsend, Mitchell & Carter, contractors, is using two trains of tractor-drawn wheel scrapers consisting of two 5-ton Holt "caterpillar" tractors, and four Maney 4-wheel scrapers.

The Dixon-Henderson road is a Federal Aid Project, forming part of the Dixie Bee line running from Chicago to Florida. The section under consideration (Project 39, Sec. C) is about 5 miles long, and winds around the Kentucky hills with few level stretches, and with grades of from 2 to 6 per cent.

Road Grading With Tractor Drawn Wheel Scraper Outfit: (1) Loading. (2) Hauling Loaded Scrapers. (3) Dumping. (4) First Outfit Returning; Second Outfit About to Turn.

The contract calls for moving about 25,000 yd. of dirt, putting in some 20 concrete culverts, and clearing and grubbing about 2½ acres of ground. Free haul is 500 ft. with an overhaul of about 13,000 ft. on 5,000 yd. The soil is limestone clay, free from rock.

Work was started in September, 1920, with teams alone. Operations were stopped for the year on Dec. 17. During the last month and a half, "Caterpillar" tractors and scrapers were used, replacing all except 4 teams. In 1921 work was begun on April 4 with the same equipment (tractors, scrapers and 4 teams).

Method of Operation.—The method of operation is to use the "Caterpillar" tractors on hauls of 150 ft. and up, and teams and slip scrapers on all of the shorter hauls. This forms an ideal combination, and gives the contractor an equipment so flexible and efficient that he can handle any given condition with maximum economy.

The efficiency of teams is well known on hauls of around 100 ft., on hauls across the road, knocking down short, steep banks, filling up deep holes and washouts, etc. But where teams begin to cost real money is on the longer hauls. It is this condition that the "Caterpillar" drawn wheel scrapers handle best. The following are typical examples of the amount of dirt these outfits have moved: Working up and down a 6 per cent grade that was to be cut to 5 per cent, on an overhaul of about 1,300 ft., Mr. Mitchell found that one "Caterpillar" outfit averaged him about 120 yd. a day, the two outfits gave him about 240 yd. On another hill, of 5 per cent grade, he found he was averaging around 200 yd. with each outfit on a 600-ft. haul; both outfits gave him 400 yd. per 10-hour day.

The power units consist of two 5-ton "Caterpillar" tractors hauling 2 scrapers apiece. Six men are employed as operators: 2 on the tractors and 1 on each of the 4 scrapers. On hauls of around 200 yd., one power outfit loads 180 yd. from the fill; second outfit 220 yd. from fill. This prevents delays. On longer hauls this is unnecessary. The road is about 24 ft. wide, which gives ample room for passing at any point. The "Caterpillars" turn the scrapers easily within this radius, and when necessary can turn within 18 or 20 ft. In going over or turning on soft fills, up grade, or through mud, the "Caterpillars" have ample power to pull the scrapers. In fact, Mr. Mitchell handles all of his tractor operations on direct gear, rarely if ever using low gear of the tractor, which gives approximately twice as much power.

One scraper man is generally used to handle a train of 2 or 3 Maneys behind a 5-ton "Caterpillar," but Mr. Mitchell has found it better economy to use one man on each scraper for the following reasons:

1. They take better care of scrapers and keep them in better running order.
2. They take a great interest in their particular scraper.
3. They like job because seat is very comfortable and work is not hard.
4. They can get a bigger load per trip.
5. They can make a smoother, evener cut.
6. They are a great help in the morning, speeding up work of greasing tractor and scraper wheels.
7. They provide an extra man for an emergency.
8. They cost little. With dirt paid at the prevailing rate, and the extra operator getting $3, a few more yards of dirt pays his daily salary.

Start Work Quickly After a Rain.—After a rain operations can be resumed very quickly on account of the track laying construction of the "Caterpillars," which gives them a firm footing over soft ground. A thin cut is made to take off the top layer of mud. The sub-soil then encountered is dry, and there are no further difficulties. Plowing is unnecessary except in one or two cases; notably when making deep cuts of from 7 to 10 ft., it is sometimes necessary to plow through the very hard clay found at this depth.

Before starting work on any particular section, the stakes are taken out and set on one side of [illegible]. Particular attention is paid to getting down to grade [illegible] crown; the sides being later finished with an [illegible] pulled by one of the "Caterpillars."

Mr Mitchell has found that his four [illegible] are particularly useful in smoothing out the road ahead of his wheel scrapers. For example, on coming to a [illegible] 30 ft. wide with nearly perpendicular banks about 8 ft. high that crossed the right-of-way, he worked his teams with slip scrapers all day, filling in the bottom and plowing the banks down somewhat. When he had made roughly a 25 per cent grade out of the banks, he moved his teams up farther ahead and put his "Caterpillars" and Maneys to work on the fill. As the two outfits dump 4 full yards on every trip, the remainder of the fill was made in a short time. Such obstacles as trees, hedges, stumps and heavy roots are either dragged out by the "Caterpillars" or chopped out by hand. The contractor is doing his own concrete work, and is using a small 1-bag mixer.

The equipment and organization on the job are as follows:

EQUIPMENT.

2-5 ton "Caterpillar" tractors.
1 Maney four wheel scrapers.
4 No. 2 slip scrapers.
1 plow.
1 blade grader (8 ft.).
1 Dodge touring car.
1 International truck.
1 concrete mixer (1 bag).
75 ft. of chain, ⅝ in.
Small tools.

PERSONNEL.

1 contractor.
2 tractor operators.
4 scraper operators.
4 mule team drivers (hired with teams).
1 dump man.
1 roustabout.
1 man for clearing right-of-way.
1 loader (for teams).
1 truck driver.
1 concrete mixer foreman.
5 laborers on mixer.

Below is given a table of capacities showing amount of dirt the 5-ton "Caterpillar" has moved daily, hauling 2 and 3 Maney scrapers, respectively:

DETAIL TIME TABLE FOR 5-TON "CATERPILLAR" PULLING TWO 4-WHEELED SCRAPERS.

Length of haul in feet	300	600	900	1,320	1,800	2,640
Round trip time	3 min. 55 sec.	5 min. 35 sec.	7 min. 25 sec.	9 min. 50 sec.	12 min. 25 sec.	17 min. 25 sec.
Cubic yards per trip	2	2	2	2	2	2
Cubic yards per 10-hr. day	262	214	160	122	96	68

DETAIL TIME TABLE FOR 5 TON "CATERPILLAR" PULLING THREE 4-WHEELED SCRAPERS

Length of haul in feet	300	600	900	1,320	1,800	2,640
Round trip time	4 min. 15 sec.	6 min. 10 sec.	8 min. 10 sec.	10 min. 35 sec.	13 min. 20 sec.	18 min. 10 sec.
Cubic yards per trip	3	3	3	3	3	3
Cubic yards per 10-hr. day	360	270	210	150	120	90

The above calculations are based on round trip times, that include over 15 per cent for lost time, or more than 1½ hours per day.

The table is not intended to show an absolute or guaranteed daily yardage. It was made from operations run under average conditions on level ground, and shows results that may be expected if the outfit is efficiently handled.

Below is shown dynamometer record of 5-ton "Caterpillar" pulling three Maney 4-wheel scrapers, which was taken Feb. 15, 1921, through rolling field. Soil, medium damp clay, showing all phases of operation within guaranteed drawbar horsepower of the tractor.

POUNDS PULL ON DRAW BAR.

		Maximum.	Average.
Loading first scraper		6,[illegible]	[illegible] @ 1½ miles per hour
Loading second scraper		5,800	[illegible] @ 1½ miles per hour
Loading third scraper		6,000	4,800 @ 1½ miles per hour
Hauling loaded scrapers	Maximum		2,800 @ 3 miles per hour
	Minimum		1,600 @ 3 miles per hour
	Average		[illegible] per hour
[illegible]	Maximum		[illegible] per hour
	Minimum		[illegible] per hour
	Average		2,540 @ 3 miles per hour
Turning empty	Maximum		1,360 @ 3 miles per hour
	Minimum		960 @ 3 miles per hour
	Average		1,160 @ 3 miles per hour
[illegible]	Maximum		[illegible] per hour
	Minimum		[illegible] per hour
	Average		[illegible] per hour

The pounds pull on drawbar required to load first scraper is higher than that required to load second and third, because scraper operator took an extra deep bite with his pen and took up a load greater than 1 cu. yd.

From costs on four months' time already put in on the contract, Mr. Mitchell figures that his "Caterpillar" tractor outfit shows him a saving of from 20 to 25 per cent over the cost of doing the same work with teams. His outfit is so flexible that it can be efficiently applied to any conditions likely to be [illegible] without loss of time and in the most economical way.

Fundamental Economic Considerations in Locating and Designing Highways*

By E. W. JAMES,

Assistant Chief Engineer U. S. Bureau of Public Roads.

In approaching this discussion and in endeavoring to establish the identity of a fundamental consideration, as we must at the outset, I submit that there are two distinct classes of engineering structures in the general group known as public works. The first class is purely technical; the second class purely commercial in character. The technical class deals with engineering problems from the purely scientific and professional point of view and designs regardless of cost and with no thought of a return. The commercial class deals with structures on an economic basis and gives every possible regard to costs and probable returns. The line between these two classes is not clearly defined, and one class merges gradually into the other. Illustrations of the purely technical extreme are found in some monumental public buildings, parks and grounds; in river and harbor work; in practically all military and naval construction. The commercial class is represented in greater or less degree by proposals to have the Government construct modern office buildings with the proceeds of a bond issue which could be floated and amortized for less than the present expenditure in rentals; by drainage and levee construction where costs are allocated to the acreage reclaimed or protected, and must, therefore, be determined on the basis of commercial agricultural values; and by the Reclamation Service operations.

In view of the current magnitude and the rapid increase of expenditures for highway construction, there appears no possible doubt that the time has come to place highway location and design, as public works in the class of commercial structures and to handle the work accordingly. The latest figures compiled by the Bureau of Public Roads show that approximately $520,000,000 were expended on rural highways in 1919. This amount represents an increase of about one-third over the expenditures for 1918 and is some $220,000,000 more than the rural highway bill for 1914. A few years ago, when the per cent of pleasure tonnage included among motor-propelled vehicles was much larger than it is today, the writer thought that we were justified in charging an indeterminate but considerable part of the real cost of our roads to the same account to which we charged our national expenditures for tobacco, alcohol, chewing-gum, soda water and the "movies." That time has certainly passed, because the demands of traffic for heavier construction and greater refinement of design have already come perilously near the field of unknown in highway engineering. Increased weight and refinement of design are costing large sums and the highway engineer who would today disregard these matters and confine himself solely to technical considerations would be treating his reputation most disdainfully.

New Adjusments Required to Meet New Demand of Traffic.—By 1914 we believed that we had met successfully the demands of motor traffic. The question then of greatest importance was that of surface abrasion, involving intimately methods of construction that would produce exactness of line and uniformity of surface. Today the whole field of highway engineering is reopened and we find ourselves looking for new adjustments satisfactory to meet new demands of traffic. Purely technical questions may be mentally summarized in the proposition: If a 4-in. concrete road fails; if a 5x7-in concrete road fails; if a 6x8 concrete road fails; and if an 8x10 concrete road shows unmistakable signs of failure under current interurban traffic before the final voucher is paid and the contractor released, what design will be adequate? The economic questions may be similarly represented by the proposition: If an 8x10 concrete road costs $80,000 per mile and shows certain signs of inadequacy before completion, how can highway engineers justify such costs and how can the huge investment of public revenues in high way construction be protected against becoming a dead loss?

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*Paper presented Feb. 9 at the Highway Engineering Conference at the University of Pennsylvania.

The Economic Considerations.—For convenience we shall consider these queries in opposite order.

The answer to the second is that the highway engineer can justify himself only by showing that in any given case the strongest possible reason exists for the construction of the road, and that every possible economy has been secured in its construction.

It appears that a complete consideration of the matter may be stated under three general heads:

1. Economics of locating, broadly considered.
2. Economics of physical design, which is largely drafting board work.
3. Economics of materials.

In the first place, we need only consider roads to be newly improved; for in the case of old roads, the work usually follows predetermined lines, present development and usage. Substantial changes are not generally possible. In the eastern states where a large mileage of improved roads already exists, where population is comparatively dense and more uniform than in other sections, and where lines of travel are established, local changes are almost always difficult to effect.

But even in such conditions when it becomes a question of adjusting routes, in distinction from short roads, or sections of roads, then we have a choice, and careful economic study must be resorted to to justify improvement.

The most important consideration is population served. This is an index of all development. The curves of population and assessed valuation of the states of the Union, or of the counties of a state, show a marked degree of parallelism. Population produces more traffic than any other economic factor.

The next most important consideration is present agricultural development. This represents commodities perishable to a considerable extent and widely scattered and is one of the strongest justifications for improvement. Over considerable areas agricultural produce may be delivered for daily consumption and in such territory the very large expenditures may be justified by a full showing of the value of service rendered.

Next in order we must consider industrial development. This is of less importance than those factors already considered because when outside of large centers of population, individual industrial plants are generally on the line of rail transportation and most of their products are shipped to distant points. In cases, however, where such industrial plants exist, they add weight to the reasons for expensive improvements.

Finally, we must consider all phases of possible future development. We should evaluate the arable land contiguous and tributary to the route, foresee town sites, the growth of small towns, the development of water powers and the expansion of industry.

The Justification of the Highway.—The economic justification of route locating on a large scale will not be much affected by the general plan of layout adopted as some may suppose. It makes but little difference whether we approach the general problem with the intention of developing an extension of the railroad transportation system or whether with the idea of creating an independent system of highway routes. When we come to consider the details we find that these purposes become identical. A scheme of radiating roads about important railroad shipping points, if extended inevitably becomes an independent system; because eventually extensions between shipping points will connect as more and more of the intervening territory is given service, and the railroad will be paralleled by highways between stations. The justification of the highway has little relation to the parallelism, but depends on the development seeking outlet to the railroad shipping points. We shall find the two broad conceptions of highway systems—an extension of the rail systems as independent—closely analogous in so many other respects that little difference will be made in our economic justification of routes when we come to detail analysis, whether we have adopted one conception or the other. This may not seem to some a sound position, but on careful consideration I think it will be agreed that so far as justifying the details of large highway systems, we may for all economic purposes consider the railroads as running underground between important shipping points.

Methods of Establishing Economic Justification of a Highway System.—The methods to be used to establish economic justification of a highway system largely considered, are principally statistical. Our best source of general statistics is the Bureau of the Census, and a convenient compendium of statistical matter is the annual abstract published in a convenient volume. This contains collated and edited statistics as well as those secured by enumeration.

Then we have special studies of local conditions. Figures must be secured regarding acreage of land under cultivation and cultivable. The tonnage of produce calls for knowledge of prevailing crops. Where tobacco is a staple, we find the prizing house records excellent; in the cotton states the gin reports are good, and the records of local freight shipments are always usable. These and similar data should be secured and carefully tabulated. Generally some estimate of future growth of a general sort can be made from the comparative figures of the census. Interest is so keen in the increase and change of population that it is not usually difficult to secure factors of change applicable locally.

One of the most convenient methods of applying the statistical data is through the graphical layout. Any convenient system of mnemonics may be used. This applies as well to the United States as a whole as it does to a county in a sparsely settled state. For instance, if the problem were submitted to us to locate the most important highway route across the United States, we could determine its starting point on the Atlantic, its general layout as its terminus on the Pacific, and justify our solution economically. We could continue to discuss such a problem state by state and finally county by county and determine throughout the route that as a whole it would be more important than any other route that could be selected.

Very often the economic location in a large way is almost obvious to one possessing a fairly large fund of general information of the territory he is working over. But even in such cases it is well to be possessed of definite figures, for the highway engineer more than all others is criticised unfavorably for his decisions; and it is doubtless a fact that less preliminary investigation is made considering the expenditure involved in highway construction than in almost any other line of general engineering.

A friend of the writer's, a sufficient authority on highway bond issues to have written an accepted treatise on the subject, recently said that in many counties and generally throughout the country the basis of issue for highway bonds appeared to be decreasing at a rapid rate. This condition was assigned to the fact that too many large issues had been made without adequate study of the economic features involved.

The Economics of Physical Design.—We must next consider the economics of physical design involving alignment, grades, structures and cross-section design.

The alignment includes the details of engineering location, purposely excluded from the discussion that has preceded.

The fundamental economic consideration is distance, and it affects the highway structure as a whole in three distinct ways: (a) Through the cost of construction, (b) the cost of maintenance, and (c) the cost of using.

In discussing the cost of construction we must digress for a moment to consider what the cost of construction really is. In the past many engineers in attempting to compute the comparative costs of road improvement to a community have placed interest on bonds and sinking fund items in the annual charges involving the maintenance of the highway. This is distinctly incorrect. Such charges as are required for interest, annuities, sinking funds, or serial retirement of bonds should be added to the first cost to determine the whole cost of the improvement new to the community. These details have no relation whatever to maintenance, and constitute nothing but a more or less costly machinery for financing construction. The cost of the machinery should be added to the capital charge for that purpose. If this is done as it should be, the real cost per mile of a road generally reputed by present methods of statement to have cost $80,000 per mile, if built from the proceeds of a 25-year bond issue, would cause some of our fellow citizens the utmost astonishment.

When we are considering the maintenance of our roads, however, we must not ordinarily charge any interest. It has all been taken care of in the cost of construction. If, however, we are using maintenance costs to [illegible] different roads, then we should use the same assumed interest on the total cost of construction. These values represent the total real annual comparative costs to the community of owning these two roads. If we wish to determine merely the real annual cost of owning the road, the interest item should be omitted as no public accounting considers the interest charges against public works once the underwriting machinery is paid for.

The cost of using a road, like the cost of construction and the cost of maintenance, varies directly but not necessarily in the same ratio with the distance; and alignment, therefore, should always tend to a minimum. This appears obvious; but just as soon as we begin to consider grades, structures, and cross section design we see at once that what is an obvious tendency becomes as elusive as most economic principles.

In considering grades we find that the fundamental consideration affecting the cost is total rise and fall. The cost varies directly with reduction of grade in a given distance, and the distance varies inversely with reduction of grade for any given cost. It becomes necessary, therefore, to determine the comparative effects of reduction of rise and fall and change in alignment. Join to this the cost of using the road and we have the same problem that confronts the railroad engineer. But we must note that we have more indeterminate terms involved than we can well handle. In fact, we have about reached the limit of what we might call the data of highway engineering. In the first place, we cannot do more than assume the effects of grades on the cost of use. There is practically no information regarding the comparative cost of maintenance on grades of different degree. We cannot today determine in any given case what alignment and set of grades is the most economical, and we might as well admit it. All we can say in our own defense is that, while we do not know, no one else does either; and we have the great advantage of knowing how to get the information. We are spending tens of millions of public money, county, state and national; and because of the tremendously rapid rate at which highways have been demanded and financed we have not been able to keep abreast of the demands of the profession. In mere technique no one doubts that we have overtaken and passed the great road building organizations of Continental Europe, but they as well as we must not forget that we are to justify enormous budgets and we should adopt a corresponding professional attitude. The widest possible association and familiarity with county, state and national road work surprises me because of the lack of careful study and economic adjustment. Comparatively few states regularly furnished balance points for excavation until they were required. In most cases this meant, as might be supposed, that the mass diagram was not used to study the economics of the grade as laid and that the work was designed in a hit and miss fashion. We may be excused for not using data that cannot be secured, but certainly we should not omit any reasonable means of determining the economic design of our work that is available today.

Lines of Investigation that Should Be Undertaken.—From this point the discussion of the fundamental economic considerations in designing highways will consist largely in the enumeration of lines of investigation that should be undertaken and advanced as rapidly as possible, together with some citations of work under way and projected.

The first element of design that confronts us is selection of type, and it might be briefly and accurately added that in this selection we are confronted with most of the unsolved problems of highway engineering. We have very little accurate data on which to base a selection of type. A recent paper by one of our state highway engineers contained the statement that the traffic census was of little or no value under present conditions in assisting us to decide on the type of construction. The statement is substantially correct. If we have the figures of an elaborate traffic census expressed either as the number of vehicles, the ton miles of traffic, the ton miles per foot of width or the number of units of maximum weight, we cannot on the basis of these figures determine whether a gravel road, a bituminous road, or brick or concrete will certainly be required to carry the traffic and we are still further from being able to produce a detailed cross section design for the purpose. To be able to use such information, we must know in detail the effects of a given traffic on the various types of surface. We must know the cost of maintenance of each of those types under the traffic in question. We must know how the strength of the surface itself is affected by foundation conditions. Practically all of such information is today in a very fragmentary condition.

For a number of years the Bureau of Public Roads maintained experimental sections under close observation and correlated the maintenance costs and the traffic. The French system of recording the latter was used and the most accurate possible figures obtained. We were able to develop the fact that cold water gas tar surface treatment on limestone macadam could be economically maintained under 600 ton miles of traffic per day, but that the same type could not be economically maintained under 800 ton miles per day. On the other hand, a hot tar surface treatment was adequate and economical for the 800 ton miles of traffic. Some other facts of value were learned, but nothing has ever been done of which the writer is aware which will establish similar information as between gravel and water-bound macadam or between water-bound macadam and the bituminous types or between brick and concrete. This is a line of investigation which involves fundamental economic considerations of design and considerable expense is justifiable in carrying out the necessary studies.

A number of engineers and some organizations have attempted to give in tabular form the limiting amounts of traffic that may safely be assumed for the several types of surfaces, but all of these efforts are based on engineering judgment of a very general kind and not on observation or exact figures.

The Bureau of Public Roads has done considerable investigating of the effects of heavy units and it appears possible that the best method of expressing traffic will be found to resemble the French system of expressing traffic in collars or yokes, but instead of using as the unit so light an element as the French collar, the heaviest motor truck should be used.

The questions are at once raised, "What is the heaviest motor truck?" and "What is the effect of that truck on the various types of surface." The railroad bridge engineer has the very definite Cooper loadings and he begins his calculations with definite assumptions, but until some general control of traffic through uniform traffic laws is had throughout a large part of the United States, the highway engineer can make no definite assumptions, but must use his judgment and his knowledge of the probable traffic developing in the locality. It is interesting to see how this detail alone affects highway bridge construction. When the United States was operating on the Mexican Border, a motor truck train was operated from Chicago to El Paso for the purpose of learning so far as possible what were the requirements in operating such a military unit across country. The captain in charge of that train informed the writer personally that in the state of Arkansas 100 bridges failed in the course of the journey across the state. Since the enormous development of military motor traffic during the war, another motor train was operated over the Bankhead Highway. An engineer of the Bureau of Public Roads accompanied the train across the state of Arkansas and his report, which was in general accord with the opinion of the officer in charge, indicated that for all practical purposes it would be impossible to depend on motor transport in that state for any except local purposes. On the other hand, such trains actually operate in the state of New Jersey without serious difficulty. Until traffic control laws are sufficiently uniform and general, it will remain an open question whether Arkansas should design to meet conditions that New Jersey is already meeting.

In some of the states where highway development is most advanced, roads of all types went to pieces during the first winter after the United States entered the war, indicating that motor traffic had developed to a point beyond the margin of safety unconsciously assumed in the earlier designs of our best roads. Many of the failures were attributed to foundation conditions and the Bureau of Public Roads at once began investigations to ascertain the bearing power of soils under highway surfaces. These investigations are now in progress.

Until these studies and others of similar nature have been completed in a sufficiently general way we cannot at this time intelligently design the most economic type of highway for any given traffic. We have gone far enough, however, to know that the prevailing practice of designing a single uniform cross-section for indiscriminate use up hill and down, over a long mileage of construction is not satisfactory. Consideration must be given to the underlying soil and sub-base designed as necessary in sections often less than a station long which will correct deficiencies in the foundation. It is probable that the properly designed highway of the future will not have the same cross-section in any two consecutive quarter miles although the surface after completion may present a uniform appearance.

When we begin to consider the economy of operating on a given surface, we find again that information is lacking. A recent schedule of investigations proposed by the National Research Council Committee on Economic Theory, Division of Engineering, contains three groups of 29 problems and a fourth group still remains to be elaborated. This study is confined to the determination of the cost of operating on various types of surfaces and on various grades.

Arrangements are being made by the state of Illinois to construct under service conditions a long mileage of road from which miscellaneous traffic will be excluded and over which various types of motor vehicles will be operated until the road is practically destroyed. It is believed that the information secured will thoroughly warrant the cost of the experiment and be valuable in effecting large saving in the design of heavy traffic roads in the state.

Economics of Material.—Our next general consideration has to do with the economics of materials. Under this head much more information is available than under the previous one because methods of testing materials have been thoroughly developed. We still lack, however, the necessary correlation between the laboratory tests and the action of the material in service. Such data can only be secured under careful maintenance organizations where construction of a definite type exists, using material which have been tested and whose characteristics are, therefore, known. At the present time we assume certain French coefficients as indicating rock of a quality adequate for various types of construction. Most of these assumptions are based on judgment and general information and not on actual data.

Without extending this discussion further we can see clearly that although we may formulate the fundamental economic considerations in location and design and although in the matter of general location and routing of highways we can without undue expense arrive at definite established conclusions, we, nevertheless, lack a large amount of the information necessary to produce an economically designed cross-section.

Thoroughly alive to this condition the secretary of agriculture asked congress for authority to spend a considerable sum allotted from the 3 per cent fund under the Federal Aid Act for co-operating with the various laboratories and investigating agencies of various engineering societies in studying problems now difficult or impossible of solution with the data available. The amount of work to be done is so great that the effort must be systematized and duplication reduced to a minimum and the experiments made as practicable and directly applicable as possible. If the authority asked is secured, the work will doubtless be done in co-operation with the National Research Council under the direction of thoroughly responsible agencies and it is to be hoped that within a few years the data of highway engineering will be sufficiently complete to enable the Highway Engineer to face the fundamental economic considerations arising in his work with the necessary means to meet them.

Road Building to Be Discussed at Chicago Meeting of Am. Soc. M. E.—The new Materials Handling Division of the American Society of Mechanical Engineers is planning sessions for the discussion of "Design and Construction of Machinery for Road Building" at the society's spring meeting to be held at the Congress Hotel, Chicago, May 23-26. Four papers will treat this problem from the viewpoint of the contractor, the road builder, and possible future development of mechanical equipment in road building.

Paving at Gasoline Service Stations.—The Standard Oil Co. of California, according to its February bulletin, is constructing asphaltic driveways at many of its service stations. The pavement consists of a 3½-in. asphaltic concrete base and a surface of 1½-in. sheet asphalt or asphaltic concrete (coarse aggregate mixture). Around the filling pumps, a space 12 to 15 ft. long and 8 ft. wide is painted with a paint that will resist the effect of gasoline.

Care of Asphalt Paving Equipment

In a brochure, "Suggestions for Asphalt Paving Contractors," prepared for The Asphalt Association, Mr. Henry B. Drowne, Division Engineer of The Lane Construction Corp., Meriden, Conn., has given some of the results of his experiences and observations of the past 15 years in highway work. The notes following on the care of construction plant, are taken from advance proofs of the brochure.

Care of Small Tools.—All new small tools upon receipt should be branded with the owner's name. Some contractors go as far as to paint the handles, but such an expense is hardly warranted. Sufficient tool boxes should be provided on work and at such points that upon quitting work the men can put the tools they are using in them. Many dollars worth of tools are lost in a season if men are allowed to put the tools at night in other places than the tool box. An occasional inspection of small tools as to their condition with the idea of having dull tools sharpened and worn tools replaced with new ones is advisable.

Tool boxes, wagons, rollers and all other large equipment should be given a number for purposes of identification and record. The maker's number will suffice on plant which may bear such a number. For purposes of publicity, it is a good idea to place the company name on all plant and on any plant that requires painting, to use the same distinctive color scheme throughout.

A contractor doing a large amount of work necessarily has a large equipment. It is a prohibitive expense to bring all such plant together at some central point when not in use. The usual practice is to store plant locally at the completion of work and reship as needed from the different points of storage to the new work. Such a method is inexpensive and frequently makes a movement of plant on to new work very cheap where new work may be taken at a point near the vicinity of storage.

Winter Storage of Equipment.—Tool boxes and small equipment should be put under cover for winter storage. It is also preferable to put wagons under cover. Where it is necessary to leave them in the open, if the bottoms are opened and the wheels raised so as not to be in the mud, the wagons will not be harmed even in a severe winter. At the end of the season, all wagons should be repaired and given a coat of paint, if necessary, and put in shape for next season's work. Frequent painting will add considerably to the life of any plant composed of wood. Gas engines and pumps should be thoroughly overhauled, replacing the worn parts with new ones.

Steam rollers, boilers, asphalt mixing plants, distributors, crushers, and other large plant are frequently difficult to get under cover for storage. Such plant if left outside, by taking a few precautions, will weather the winter without harm. With heavy plant, it is always advisable to choose a location for storage that will be accessible early in the following season.

Care of Asphalt Plant.—All accumulations of dirt, rust and scale, on an asphalt mixing plant should be removed after completing a job, and all metal surfaces should be given a coat of asphalt paint. The fire box under the drier should be examined and new bricks and grate bars replaced where necessary. All badly worn gears should be renewed. Kettles should be thoroughly cleaned out at frequent intervals while operating. When in operation proper lubrication of bearings and gears does much to prolong their life.

When operating distributors the nozzles and screens should be frequently cleaned to prevent clogging. Accumulations of asphalt should be occasionally removed. Safety valves and gages should be cleaned and tested to see that they are in proper working order. The air pumps give very little trouble.

Care of Steam Engines.—Any steam engine, whether on a roller or other piece of plant needs frequent attention. Given good care, a steam engine will last for a long time, but a careless operator will ruin one in a short while. Proper lubrication goes a long way in prolonging the life of an engine. Each oil and grease cup should be kept full of the right kind of lubricant, and the feed should be regulated as required. Manufacturers usually send instructions with their machines recommending the kinds of oil and grease to use for lubricating the different parts. While too much oil in certain instances may be detrimental, it is always better than not enough. A sight feed lubricator should be placed on all steam cylinders. Engines should be kept clean.

An unusual sound in an engine [illegible] wrong, as a steam engine in good condition should be free from noise. Knocks usually are due to looseness in the wrist pin, crank pin, or some of the bearings, and they may be eliminated by taking up the play at these points. Bearings should not be taken up so tight, however, as to overheat.

Before starting an engine, see that no obstructions are in the way to interfere with its operation. Open the drip cocks in the cylinder and blow steam through the cylinder to warm it up and free it from water. In cold weather, water should be drained off each night from the cylinders and from any point where it is liable to freeze.

When an engine is laid up in storage it is advisable to remove all fittings that might be easily stolen. All bright parts should be daubed with a heavy coating of oil to prevent rusting. The cylinder heads and steam chest covers should be removed and coated on the inside with good cylinder oil and then replaced. Steam engines which are used in highway work are commonly of the slide valve type. Unless the valves are set properly, the engine will not operate efficiently. Valve trouble is usually indicated by the sound of the exhaust, loss of power, and change in dead point The exhaust seems to be harder on one side of the stroke than on the other. It is an easy matter to reset a valve and any competent engineer can do it.

The Care of Boilers.—Annual inspection of boilers by a properly qualified person is required in some states. When a contractor carries insurance on his boilers, annual inspection of them is made by employes of the insurance company issuing the policy.

In the operation of boilers, safety should be the first consideration and when doubt exists as to the strength of any part of the boiler, it should be filled with water and tested by hydraulic pressure to one and one half times the working steam pressure. Bulging plates are always a sign of neglect and if the crown sheet is bulged, it is a pretty sure sign that the boiler has been run sometime with low water. A dirty condition of the boiler will also cause the crown sheet to bulge and is responsible for much of the other troubles common to boilers.

It is essential to keep the inside of a boiler free from dirt and scale, not only to prolong its life, but also to enable it to work at its highest efficiency. The interval at which such cleaning will be necessary will depend largely upon the method of taking water and the source of the water supply. Some waters form a scale much more rapidly than others. Operators are careless many times in filling the water tanks and more or less fine sediment is drawn up with the water which later finds it way into the boiler. Accumulations of sediment cause tubes to leak and metal surfaces to crack and bulge. The hand hole plates should be removed and the inside of the boiler should be thoroughly washed out at least once a month. The dirt and scale should be loosened by scrapers and flushed out with a hose carrying, if possible, a supply of water under pressure.

Any stay bolts, which are broken, should be promptly renewed. If any plates require patching, such work had better be done by a boiler maker. Leaky flues can frequently be made tight if in not too bad condition, by rerolling the ends with a tube expander. Tubes should be cleaned once a day by scraping them out. The exposed end of the fusible plug should be kept clean and new plugs should be put in occasionally. The use of any other kind of plug than one filled with pure tin or other suitable filling material should never be allowed.

Ashes should not be permitted to accumulate in the ash pit, for if they get within a few inches of the grate bars, these will become overheated and warped, and new ones will be necessary. Before starting a fire in a boiler, be sure of the water level. Watergage cocks should be kept in working order so that they can be depended upon in determining the water level rather than the water glass.

A thin and even fire is more effective and economical than one where too much fuel is used. Injectors should be kept in good repair so that they can always be relied upon. A boiler should never be entirely blown down at a pressure over 10 lb., and it should under no circumstances be refilled with water until it has completely cooled off.

A boiler should be blown down slightly once or twice a week, and completely at the end of a job. If a boiler is found at any time with low water, cover the fire with ashes or fresh coal and shut off the draught. Do not under any circumstances add more water, but allow the boiler to cool down gradually.

When laying up a boiler, it should first be thoroughly cleaned inside and out, the fittings should be removed and boxed, the outside should be given a coat of heat resisting paint, and the end of the smokestack should be covered over to keep out the water.

Have Plenty of Spare Parts on Hand.—Certain parts of a machine deteriorate more rapidly than others and it is always advisable to anticipate the need of spare parts by having some on hand to replace those which need renewal The old adage that "an ounce of prevention is worth a pound of cure" was never truer than in the case of machinery. Proper care and renewals of worn parts will prevent serious breakdowns and much lost time.

Plant Depreciation.—The contractor who owns plant and fails to charge off anything for depreciation is fooling himself as to the amount of money he is making. There are a number of methods of calculating depreciation, the simplest of which being the one where the rate of annual depreciation is one divided by the total number of years of life of the machine in question.

The life of some equipment is much longer than others. The use to which equipment is put, the care which is given it while operating it, the condition of repair it is kept in by the renewal of worn parts, are all factors which affect the life of any machine or other equipment.

A contractor should at the end of each year examine his equipment and assign values to the different pieces of plant in order to determine the amount of capital actually invested. The difference in book values of the same plant from year to year will be the amount of depreciation. Money charged off for depreciation should theoretically be set aside and allowed to accumulate for the purchase of new equipment. The successful contractor, however, can make such money earn larger returns by using it in the business than by banking it, or otherwise investing it. In any event, it should be kept track of in the office records and never counted in with the profits.

Physical Properties of Some California Adobe Soils

In connection with the engineering study of the state highways of California, made for the Automobile Club of Southern California and the California State Automobile Association, tests of adobe soil were conducted at the University of California by C. T. Wiskoril, association professor of civil engineering. A preliminary report on these tests is embodied in a general report which was recently made public, as noted in our issue of March 2. The tests were made on 13 different samples of adobe soil submitted from 5 counties The report states that the conclusions are tentative, because further studies, particularly on other samples of soils, may modify or enlarge the views. The results obtained, which apply only to the particular soils studied, are summarized as follows:

1. Adobe soils increase 1½ per cent in volume from oven to air-dry conditions.
2. Air-dry adobe soils contain about 6 per cent water.
3. Air-dry adobe soil when made into a stiff mud (a condition of plasticity not easily defined) will increase 37 per cent in volume. (The range for the soils used was from 16 per cent to 51 per cent.)
4. Air-dry adobe soils made into a paste that could be poured will increase 67 per cent in volume. (The range was from 28 per cent to 93 per cent.)
5. Different soils require different percentages of water to bring them to the same degree of plasticity.
6. Sand is not very effective in reducing volume changes in adobe soils.
7. A pressure of 430 tons per square foot was required to compact loose, air-dry, adobe soil to the density of air-dry clods (as found).
8. Confined adobe soil compacted to the density of the natural clods absorbed 12 per cent water; its inability to increase in volume produced a pressure of 63 tons per square foot. (126,000 lb. per square foot.)
9. The tensile strength of a specimen of adobe soil, taken at random, was 270 lb. per square inch.
10. The compressive strength of a specimen similarly taken was 2,500 lb. per square inch.
11. Soils classified as adobe show marked variation in grain size.

Relations Between Engineers and Contractors for Highway Work*

By W. A. ROGERS,
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Facing, as we are in this country, the beginning of a program of highway construction of stupendous volume, the relations between those who are to direct and those who are to build it is one of the most important subjects to be considered by those interested in the good roads program. The subject is so vital that it should be elaborated on in great detail which time will not permit; it may, however, be condensed in a single principle as follows: "The relations between engineers and contractors for highway work should be based on mutual confidence and co-operation."

It is certain that the immense program of highway construction planned for the next few years and amounting to many millions of dollars cannot be satisfactorily carried out without the co-operation of the experienced, competent and responsible contractors. Contractors of ability and standing will naturally seek work in the field where they are sure of fair treatment and where work can be done for a reasonable profit.

In any highway construction contract there are in theory at least three parties. Of these three parties there are the owner, who may be the federal, state, county or municipal government; and the contractor who undertakes to build the highway and receive as pay certain sums of money. These two parties, while they have a mutual interest in that they desire the completion of a certain piece of work, still are in the relationship of "buyer and seller." The third party to the contract, the engineer, theoretically is supposed to represent the rights and interests of both parties. As a matter of fact, he is employed by and is under the direct control of the owner. His position is a very difficult one and unless he is a very broad man, is an impossible one; but the nearer he approaches to his theoretical position as the representative of both parties, the more satisfactory will the relationship be.

Duties and Responsibilities of the State as Represented by the Highway Engineer.—Theoretically the engineer is the representative of the contractor as well as of the state, for the contract generally names the engineer the sole, unbiased arbitrator between the parties of the contract with power to decide finally many matters arising under the contract. This places the responsibility on the engineer of deciding what is right and fair in matters at issue between the parties to the contract and also the responsibility of interpreting the terms of the contract and specifications which he or some other engineers have prepared.

In preparation of the plans and specifications a long step towards harmonious and satisfactory relations will be made if the engineer has clearly in mind the structure to be built and describes it clearly and definitely in the specifications, leaving out all terms like "the work shall be done to the satisfaction of the engineer," etc. The contractor is entitled to have described in the specifications just what is wanted and can be followed.

In a word, they should be reasonable. Incorporating in specifications clauses which are practically impossible of fulfillment with the thought that better work will be secured by fixing up almost impossible standards is less apt to secure this result than if the specifications provide for what is reasonably possible of fulfillment.

It has been said that drastic specifications have sometimes been made for highway work with the laudable purpose of scaring away unsatisfactory and irresponsible contractors and putting into the hands of the engineer requirements which could be used to advantage in the case of irresponsible contractors, and on the other hand, could be eased up for those contractors who were doing satisfactory work.

This is entirely wrong. It has just the opposite effect. When a specification is drawn, which in any respect is not workable, it casts a cloud on the entire document and the responsible contractor feels as though he were being placed in a position where an irresponsible inspector or engineer might cause him serious trouble and expense. It is therefore in the interest of the state, the duty of the engineer to prepare workable specifications, which can be carried out with the materials reasonably available and with the human labor which we have. The highways of the country are not built under laboratory conditions and specifications and plans for highway work which are prepared with the idea that the subgrade can be sandpapered on, the materials and water entering into the concrete can be measured as in a laboratory, are not productive of the best work, but are productive of friction between the engineers and contractors and expense to both parties to the contract.

Contracts and specifications should be very definite and clear in the placing of responsibilities.

State Furnishing Materials.—I have a strong feeling that the furnishing of materials by the state is both wrong in principle and not productive of the best results, either as to harmony between the parties or as to decreased cost. It injects into the work a question of divided responsibility. It makes the state responsible for something which is part of the construction and on which the progress and economical operation of the work is vitally dependent. If the materials are not delivered in the order and at the rate which the work requires it adds to the cost, and the engineer who is not paying the bills can hardly appreciate this as does the contractor who is.

I know there is a feeling that the state can frequently buy materials more cheaply than the contractor and that it is able to allocate a restricted supply better than the individual contractors buying at random can do. This may be so, but I have a feeling that the competent contractor can ordinarily buy as close or closer and he can surely control the delivery more nearly as the work requires than the state. At least he thinks he can; and that goes a long way towards making for harmonious relationship.

If, however, the engineer does specify that the state shall furnish any of the materials, then the state should assume the full responsibility for delivery. If the state fails to deliver its materials as required by the work, thus adding to the cost of the work to the contractor, then in the interest of fairness and satisfactory relationship they should assume the responsibility for such failure. Placing on the contractor a risk over which he has no control is just adding another "gamble" to a game which is hazardous enough without it. Contracts and specifications should be so drawn that they are as free as possible from risks of this kind in the interests of both parties.

Supervision of the Work.—This is another duty of the engineer. This is a great responsibility and should be delegated in the field only to men of good judgment and experience. Inexperienced, incompetent field supervision causes delay to both the state and contractor and increases expense at the time to the contractor and eventually to the state.

Bear in mind that the data on which a contractor of experience bases his price which he bids on any job is the cost of previous work of similar character interpreted in the light of the conditions of the work on which he is figuring. In his previous costs are reflected the cost of not only every onerous clause in the specifications, but also the results of unfair and incompetent engineering supervision. It is therefore necessary and desirable that engineers in charge of highway work should be thoroughly competent. Competent engineers are entitled to compensation proportionate to their skill and experience. It is mistaken economy to save on highway engineers' salaries. Well-paid, experienced engineers are conducive to the best and most economical highway work.

There is no class of contract work which requires for its satisfactory handling such continuous operation. In order to be profitable, there must be a constant, uniform flow of materials from the point of manufacture or origin through the railroads to the unloading plant and then from the unloading plant to the mixer. Anything which tends to vary this uniform flow adds to the expense of the work. The engineer, who without proper cause stops the work, robs the contractor just as much as the highwayman who holds a pistol to your head and causes you to deliver your money. But an experienced, competent engineer will not do this.

The highway engineer should be a very broad man. He should have in mind that his job is to get as much highway built of the quality desired as can be built and at as low cost as possible to the contractor. Materials, especially sand, gravel and broken stone, are products of nature. They are not built in a factory to a certain standard. They may be graded by human care, but there is bound to be a certain variation. It seems to me it is the duty of the engineer to conform as closely to the specifications as possible, but bearing mind always the final result—that his job is to get roads built of a good quality, and that if he [illegible] tion in requirements of qualities of material [illegible] can be obtained, he should be big enough and [illegible] to meet the situation. He will realize that nature does not form the sand and gravel to fit an exact laboratory standard and that it may be necessary at times to conform to what may be reasonably obtained. This means that he will use his broad judgment and good sense in the acceptance and rejection of materials.

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*Abstract of an address presented Feb. 12 before the annual convention of the American Road Builders' Association.

Similarly with inspection of the work, it is sometimes the tendency of the younger engineers to forget that it is the final result which counts and concentrate on the minor details In other words, compliance with the specifications literally is made the important item, losing sight of the fact that what is desired is the completed highway of a satisfactory quality. Variations in the construction methods or materials which give the desired finished highway will be permitted by the seasoned engineer.

Responsible Decisions of the Engineer.—It should be one of the duties of the engineer to make fair, quick and responsible decisions. Delayed decisions are often as unfortunate as wrong decisions. By responsible decisions I mean that the state, acting through the engineer, should be responsible for his acts as the contractor. The contractor pays for his errors directly in increased costs. If through error or otherwise the state causes the contractor's work to cost more than it should, they should assume their fair responsibility financially.

Finally decisions should be made without reference to whether they will please either the contractor or the public. In work for the public like highway work or government work it may sometimes be a temptation to consider whether any decision will meet with favor of the public or not and thus have a bearing on tenure of office. The position of the highway engineer should be made free from influence of this character. And right here let me reflect, "The engineer should always bear in mind that he is in the dual position of representing both the state and the contractor."

Duties and Responsibilities of the Highway Contractor.—In the foregoing I have described some of the duties and responsibilities of the highway engineer and shown that if he fulfills the requirements of his position as many of them are he is truly a big man.

As I now turn to the description of what the successful highway contractor must do I wonder that any character can ever qualify. The contractor for highway work undertakes to determine the best source of supply for materials, which will meet the requirements of the specifications. He undertakes to see that the producers of these materials furnishes them promptly and delivers than in the required amounts at stated times necessary for the work to the railroad for transportation to the station nearest the work. He undertakes also to see that the railroad does deliver the material promptly to his unloading point. If either of these agencies fail to do their part it costs them money and time. After delivery to his unloading point, he then must unload, store, protect and then transport these materials to the site where they are to be mixed and incorporated in the finished road. In addition he has contracted to employ a competent force working under the direction of a competent superintendent, with the right sort of an organization. In the case of the contractor, errors in his judgment or of any of his organization, or lack of skill or ability are paid for in real money which shows up in increased cost.

He has also contracted to furnish an adequate and properly equipped plant for the proper handling of the work.

Each job should be studied carefully and planned properly. Whether the delivery of materials shall be by truck or by industrial plant should be settled. The method adopted for unloading and storing materials is a very large and important item and the success or failure of the work is dependent to a large degree on the plant and equipment adopted. He must provide an adequate and satisfactory supply of water. Then he must co-ordinate all of the different elements consisting of materials, water supply, an efficient crew to build the finished highway on a subgrade and finished to an exact surface. He must then see that it is properly protected and properly curved. As though this were not enough he must act as a policeman and see that the public who are eager to use the new road and can see no reason why they cannot are restrained from so doing. Sometimes when I think what the ordinary highway contractor undertakes to do, I wonder at his assumption of almost supernatural powers when he signs his contract and assumes the duty of furnishing the state a satisfactorily completed job, meeting all of the clauses in the specifications as near as humanly possible.

Above all, the contractors' organization should be made up of men who are willing to meet the engineers half way and who take a pride in the quality of their work and who are anxious to give the state an honest job. Only in this way can the highway contractor be successful. If the engineers and contractors conform to the foregoing there will be co-operation between them. There will be a realization that they are partners in a great enterprise and that the best results can only be obtained by pulling together.

Selection of City Employes Without Civil Service Regulations

From the beginning of political party government the custom of rewards to the faithful and spoils to the victors with its necessary correlation of dismissal for the municipal employe who puts faithful service above party activity or who is a poor guesser in the direction of his political activity, has prevailed, interrupted only by the civil service device. While civil service has been a great help, it has not been found a perfect antidote for the evil. How Wichita, Kan., which is under the city manager form of government, has selected its municipal appointive officers and employes without civil service regulations is told by Mr. L. W. Clapp, City Manager, in the February Kansas Municipalities. The following is taken from his article:

The legislature of Kansas adopted the commission and city manager law in January, 1917. This act was passed largely through the efforts of the citizens of Wichita. Immediately after the law became operative the city, first in the state, approved the form of city government by a large majority in an election held for that purpose and thereafter elected five commissioners at large, none of whom had ever held or aspired to any office and whose qualifications were understood to be actual demonstration of practical business capacity and success.

The law provides that the commissioners exercise their own judgment, in the organization of a working force, either with or without civil service regulations. All of these men, except one, were heads of successful business institutions which had grown up from nothing, under their own efforts and conduct. The one commissioner not a business man, as the term is usually employed, was a high type of student of good government, good morals, much interested in community welfare work, a wage earner and a leader in sane and conservative organized labor activities. He had as good as, or perhaps better understanding from some viewpoints, of the elements that constitute a valuable employe and public officer, as did the other four members of the board.

Decided Against Civil Service.—It was but natural with these men to decide, with little discussion, that civil service was not a necessary or desirable plan of selection of officers and employes in a municipal government that was expected to be operated as were their own businesses. The civil service idea was discarded.

Under the law the city's business was to be carried on by a general manager. The board of commissioners was a legislative body, a body to determine the policies of the business of city government in Wichita and to place a competent man in charge of the execution of those policies and to advise with him as do a board of directors with a general manager. The manager's duty was to select and employ all such heads of departments, officers, and either directly or through his appointees, employ all assistants and subordinates deemed necessary and competent to insure good service economically. This duty carried necessarily the right of dismissal, by the manager, at any time, of any appointed officer, head of department or other employe down to day laborer, when, in his judgment the good of the service suggested it to be desirable.

This undertaking was indeed quite revolutionary in municipal government.

A manager was employed by the commissioners in full understanding and harmony with the plan and scheme of the undertaking. No officer or employe was discharged until it became evident to the manager that he was either not in tune with the policy of business government or not able to deliver the service for which he had been selected. No person was appointed or employed for any reason other than qualifications to efficiently perform the duties of his office or position, and enthusiasm to make his department and his work a success by loyal service and co-operation with all other employes in his and in other departments. When he failed in these requirements he was no longer of service or use on the pay-roll of the city's business.

It Stopped Patronage.—One of the most interesting and astonishing situations developed almost instantly from this plan of government. The entire citizen body seemed to have at once realized that old methods of selection and employment of department heads and employes even in the wage laborer class had been supplanted and that a new order prevailed. It was the universal experience of all the commissioners and the manager, that practically no applications were made by any friends of the commissioners; none by friends of persons out of employment; none by persons disqualified from other positions, but "needing" the salary or wage; none by half competents and proven failures. The impression was general and immediate that all competent persons would be retained and only competent ones would be employed, that there was no place for sinecures and that delivery of service was an essential to continued employment.

A Wider Field for Selection Provided.—When there was not available among the business workers and citizens of the city a man for a position, the plan permitted no hesitation in seeking and employing a competent person wherever located, and available. Objection in some quarters and protest by one newspaper was made to "imported" talent, but when consideration was directed to the practice of these same protestations, in managing their own business and the affairs of the institutions with which they were associated, under which they sought out their competent men and women, regardless of place of birth, rearing or residence, the objection was soon silenced as a fallacy and without reason in logic or successful business.

Street Maintenance Methods in Small Cities*

By HARLAN H. EDWARDS,
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Street maintenance in our small cities is a task of no less importance than in our large cities. In fact, such work in cities under 50,000 is likely to be made more difficult than that in the larger cities, by the petty jealousies of some of its citizens. Its superintendence calls for the services of an engineer, a diplomat, and one with an unlimited amount of patience and courage, to direct and prosecute the work successfully.

Maintenance of Unpaved Streets.—The maintenance of dirt streets requires the judicious use of a light blade grader, the road drag or one of its combinations in the form of the road planer or one of the various makes of road machines. If the district is not well equipped with storm sewers, the services of a "handy man" are required to clean out the waterways and build new culverts, crossings over gutters, etc. There is little difference between the maintenance of dirt streets and country roads other than taking care of the drainage which, of course, is much more complicated in towns, owing to the frequent street and alley crossings.

The use of the blade grader early in the spring, to shape up such roads as have become badly rutted and pushed out of shape by winter and spring traffic, followed by a system of patrol maintenance with a light drag, is probably the best combination for this work. In order to accomplish this, an outfit consisting of one man and a 1-horse wagon, together with a light drag, pick, shovel, hammer and saw, responsible for a district totaling about five or six miles of road, has proved to be the most economical. Of course it is useless to attempt to keep dirt streets in boulevard shape in continuous wet weather, but the continuous use of such an outfit as this will do much toward keeping the streets in passable shape and improving them quickly after the wet period is over.

The use of a coating of asphaltic road oil has proved a great aid in waterproofing the road surface, and when it is used it should be applied after the road has been put in good condition. If the road has not been properly shaped and dragged, the use of oil will only make conditions worse.

Maintenance of Pavements.—The maintenance of street pavements is occasioned by the formation of chuck holes or breaks, due to the general wear of traffic, by the opening of pavements for connections or repairs to underground pipes or cables, and by the damage from poorly constructed and maintained street car tracks. Of all these items probably the last two have been the greatest cause of the shortening the life of pavements.

Methods of repair of pavements made necessary by general wear vary with the type of pavement used. The surface of bituminous pavements can be kept in good shape by the frequent use of surface treatments, using either a thin asphaltic product or a coal tar product applied under pressure by tank wagons. For the ordinary revitalizing of our asphalt or tar-bound streets, we have found "Tarvia B" applied cold, about ¼ to ⅜ gal. per square yard, to be very economical and easy of application.

A number of our pavements had cracked badly and had acquired a tendency to ravel out easily, with the formation of small chuck holes following soon after. These chuck holes were first cleaned out, then patched with a bituminous concrete mixture 2 in. thick, consisting of ¾-in. crushed stone, sand and "Tarvia K. P." mixed in the proportions of 6 yd. stone, 2 yd. sand and one 50-gal. barrel "Tarvia K. P." Two paint coat applications of "Tarvia B," about one day apart, covered lightly with coarse sand or stone chips, have put these pavements in shape so that they will be able to withstand traffic for several years longer without additional care.

Most of our troubles with brick pavements have been the replacing of a few brick here and there, the tops of which had been crushed off as a result of improper penetration of cement grout filler and the subsequent expansion due to increase of temperature, or the replacement of the worn down patches of soft brick in our older pavements. Generally speaking, our brick pavements have given us from 25 to 30 years of service, with practically no maintenance and many of these pavements are still in exceptionally good condition, and give indications of many more years' use.

Resurfacing Brick Pavement.—Much has been said of resurfacing old brick pavements with asphaltic or tar concrete, but where paving brick may be had for a reasonable price, the old brick pavements may be resurfaced by the removal of the old brick, the leveling of the sand cushion and the laying of a new 3-in. vertical fiber asphalt-filled brick pavement at a cost which will not greatly exceed that of the bituminous surfacing and will furnish a wearing surface much more foolproof and longer lived. In cities where asphaltic pavements are the rule, rather than the exception, this may not be exactly true on account of the cheapness of the asphaltic material and the availability of experienced repairmen; but in many of our smaller cities, where the mileage of brick streets constitutes the greater proportion of the entire mileage of paved streets, the cost of a bituminous surface is somewhat higher, owing to the higher cost of the mixture laid down on the street and to the necessity of shipping in a mixing plant to handle the work. Where this type of surface is laid, it must have continuous maintenance from the time it is laid and probably after a service of from 8 to 12 years, it will require a surface treatment at least once every three years.

Rebuilding Old 2-Course Brick Pavement.—In 1919 we rebuilt an old 2-course brick street about two blocks long at a cost of $2.98 per square yard, not including excavation. The old brick wearing surface and the sand cushion were removed, a 3-in. layer of concrete mixed 1 to 6 was placed on top of the old lower course of brick, a new sand cushion placed on this and a 4-in. asphalt-filled brick pavement formed the wearing surface. The brick were of the straight wire-cut variety, laid as closely together as possible and rolled to a smooth even surface. Asphalt filler was then applied by pouring cans, filling every joint from the top to the bottom. It might be well to state at this time that besides this work we have laid pavements with either the straight wire-cut brick or the vertical fiber brick with no lugs, on five other streets, a total of nearly two miles of this type of pavement and have experienced no trouble whatever from lack of penetration of the asphalt filler. In most of this work the filler was poured on and "squeegeed" into the joints.

Replacement of Pavements Over Street Openings.—The greatest source of uneven surfaces resulting in chuck holes has been improperly backfilled trenches under the pavements. On this account municipal control of the replacement of pavements over openings made in the streets for various purposes has become absolutely necessary. More trouble has been experienced and more pavements have been ruined from this cause than from any other.

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*From a paper presented at the last meeting of the Illinois Society of Engineers.

Formerly openings could be made in the pavements by any one, the dirt thrown back loosely, the broken concrete piled on top of that, the sand cushion laid and a new brick surface laid and grouted. This, of course, was bound to settle, and it formed a very dangerous hole in the pavement. The replacement of these sunken portions of pavement still form a considerable amount of our yearly maintenance.

Several years ago, however, a new method of control was adopted, making it necessary that city forces replace the dirt and the pavement, using a concrete base about 1 ft. thick and extending 1 ft. on solid ground on all sides of the trench. Since this has been adopted no trouble has been experienced from settlement.

An improvement on this type of handling the work is contemplated, however, consisting of the use of the precast 8-in. concrete slabs in sections about 4 ft. long and 2 ft. wide, reinforced with ½-in. steel rods placed 6 in. on centers and 2 in. from the bottom of the slab. As many of these slabs will be used as necessary to cover the trench completely, and they will be grouted in place thoroughly. It is hoped that the adoption of this form of concrete base will save time and will permit the replacement of pavements in cold weather when it would be impossible to lay new concrete in the street.

Organization and Equipment.—The equipment necessary to handle all this work is simple. A 1-ton truck, preferably equipped with a dump body, is sufficient to handle the material for the average small city. Along with this a small concrete mixer and an asphalt heating kettle, together costing not over $500, are necessary items. A few men, including a foreman and two or three workmen, form the nucleus of a gang sufficient to keep the streets in good repair the year round. These three or four men are enough in the winter months and may be supplemented in the summer by additional men, using the regular men as straw bosses.

The small tool equipment, of course, consists of the necessary shovels, spades, scoops, picks, mattocks, posthole diggers, axes and saws of various sizes, together with hammers for brick work and carpenter work and several 50-ft. sections of rope of various sizes. Such an equipment, supplemented by other small items when needed, will enable the men to handle almost any situation from the removal of large trees to the laying of good-sized sections of pavement or the building of a small bridge if necessary.

Effect of Car Tracks on Paved Streets.—Street car tracks are another source of trouble on paved streets and if their sphere of influence is not curbed the rest of the street is often ruined. Where stone or gravel ballast is used for street car tracks the most pronounced destruction is found, for the wave motion of the street railway track under the effect of the moving loads tends greatly to disturb the adjacent pavement. Where T-rails are used the wheels of wagons and trucks, when turning out of the track, exert a strong leverage on the paving surface and grind or loosen whatever paving materials are in the way. If the paving is loosened it is not long before the effects of water and additional motion of the car tracks disturb the pavement for a considerable distance adjacent to the tracks.

Under most franchises the maintenance of the pavement between and adjacent to the railway tracks is taken care of by the street railway companies. If the costs run much higher than the maintenance of the pavement on the rest of the street, however, the result is that the least possible work is done. It falls upon the street superintendent, therefore, to keep after the street car companies and demand careful and substantial paving repairs along and between the tracks.

In some cities the street railway companies have adopted a new type of construction for their track, wherein steel ties are used, embedded in concrete with a minimum of 9 in. of concrete beneath the rail. This has gone far to cut down destruction caused by loose tracks, as is seen very strikingly in Chicago Heights, Ill. In this city street car tracks on two streets were laid during the same year and had the same type of surface, but one used a substantial concrete base under the ties, while the other used stone ballast. At the present time the first named pavement is in perfect condition, while the other is very rough with many of the bricks along the rail considerably loosened or entirely gone. Such track construction as this may be cheaper initially, but is much more expensive for the railroad companies to maintain.

Isolating Car Tracks from Pavement.—Wherever the flexible type of construction of street railway tracks is used, however, it is practically impossible to eliminate the bad effects of the moving track and it is, therefore, necessary, if the adjoining pavement is to be protected, to isolate the street railway track completely from the paving on each side. This matter is one which has been given great thought by many capable engineers. Several designs have been made which accomplish their purpose admirably. In all these designs the concrete header or subcurb is used, extending down just outside the ends of the ties to a point several inches below the bottom of the street railway track ballast.

On some pavements, such as concrete, wood block, or granite block, this subcurb can be easily extended to the surface of the pavement, while it is hard to accomplish this without the use of a different paving material in the case of asphalt or brick with a soft filler. Even these, however, can be built with the line of separation extending to the surface of the pavement if a metal paving guard is installed in the concrete base, so that the long side of the guard extends up as a retainer through the sand cushion to within about ½ in. of the surface of the brick pavement or to the surface of the asphalt pavement.

The advantages of using the header or subcurb are several. It affords ample protection from poor track work and from the lesser movement of well constructed track, thereby reducing the worries of the street repair gang and confining the damage to the unit in which it originates. It allows tracks to be repaired, or torn up and relaid without causing damage to the abutting pavement. Repaving of the track space will be done more quickly, for the two curbs will be at the proper street level, thereby serving as a paving line during such work. This type of construction along street railway tracks is now being used by many of our most progressive cities. The expense is not great when the benefits to be gained are considered. It is the opinion of many, however, that the cost of the header curb should be borne by the street railway company, inasmuch as it is necessitated by the presence of their track in the street.

Railroad Crossing Pavement.—The pavement within and along street railway tracks, however, is not the only source of trouble. The portion of streets lying within the right-of-way of railroads at grade crossings is oftentimes the most dangerous portion of the street if not properly taken care of. The question of maintenance of the pavement in this portion of the street is one which has occupied the attention of railway and highway engineers for many years. Many different types of surfaces have been tried with the usual reversion to the old form of plank crossing. No other section of the highway must meet conditions as severe as those imposed upon the pavement adjacent to and between the rails of a grade crossing. Demands made on it are two-fold. It must fulfill the need of highway traffic and at the same time conform to the railroad requirements. As a part of the highway, built to carry modern motor truck traffic, the pavement must be of sufficient strength to carry the loads and withstand the impact caused by the wheels of heavily-laden trucks. The surface must be as durable as the highway of which it is an important link.

From the traffic point of view any pavement which will produce a smooth even surface at the same level as the bearing surface of the rail is highly desirable. A crossing free from nails, which might cause punctures or penetrate horses' hoofs, and free from jagged splinters of sharp stones which might cut tires, is much needed. Railroad operation, on the other hand, requires that crossings permit trains to pass over them without shock, danger or undue noise. Railroad maintenance demands easy access to the ties and rails and that the crossing pavement be economically repaired and replaced.

The growth, weight and volume of traffic during the past few years have made the old type of timber crossings obsolete. Newer types of pavements for this purpose have been evolved by experiment, yet the experimental stage is not over. One type consists of reinforced concrete slabs precast and set into place. Another type consists of crushed stone maintained with stone chips.

One Course Monolithic Concrete Sidewalks Versus Two Course

By MAJ. F. S. BESSON,
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Highway books in general describe two-course concrete sidewalks practically to the exclusion of one-course. Among the essential features for two course walks are stated: a base of good concrete, a wearing course of rich mortar, and division into small blocks by continuous longitudinal and transverse joints extending entirely through the concrete base.

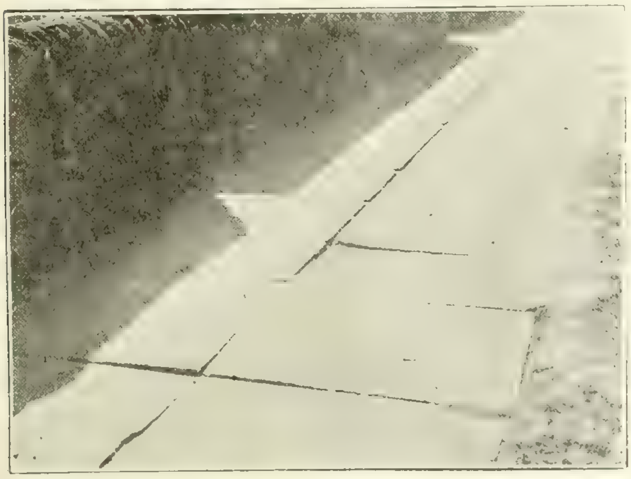

Fig. 1.—Two course sidewalk laid in 1900. Illustrating tendency of blocks to separate and present the appearance of a flag walk. The longitudinal joint has opened for the full length of the walk.

Though some cities use a one-course walk to a more or less limited extent, the District of Columbia for the past 29 years has departed from none of the above mentioned two-course essentials. From the standpoint of conservatism it is with hesitation that consideration is given to any departure from this long established practice, particularly in view of the fact that there is a lack of information on the relative value of the two types of pavement. A study has been made the results of which are described herein with the hope of developing further knowledge upon the subject.

An examination of the 1,750,000 sq. yd. of concrete sidewalk in Washington tends to the conclusion that the two course walk is faulty in that it prevents the monolithic slab action of concrete. Made joints in concrete are not fool proof and sooner or later humps appear either due to difficulties of subgrade, upheaval due to frost and tree roots, or slippage at the joint due to internal stresses in the slabs. Because of these troubles so-called expansion joints are left out of the District's specifications for concrete roads and with entire success. Natural cracks do not appear at closer intervals than the occurrence of cracks and joints under usual expansion joint practice. They are easily maintained and the concrete bordering natural cracks does not hump above the highway grade. The success obtained in road work by the elimination of made joints encourages the thought of like practice in the case of sidewalks. Some experimental work in accordance with this idea has been carried out, and certain conclusions have been reached. It would be worth much to know if these conclusions are warranted by results obtained in other cities.

Separated block pavements have been claimed necessary in order that plumbing and other cuts may be facilitated. The surface of a one course monolithic walk is readily marked into squares with jointing tools so that it may have exactly the appearance of a two course one. By cutting to these marks a patch can be made as neatly as in any other type of walk. This has been determined by trial. Also, cuts in concrete roads are of common occurrence and are repaired with every success. If economy is desired, cuts need not be carried to the square marks but may be of irregular shape. The hair line cracks that delineate such patches offer no offensive projecting edges and their mere existence is no more objectionable than that of the many cracks that occur in two course walk notwithstanding division into small blocks.

The photograph, Fig. 1, of a 20 year old sidewalk, shows plainly the objectionable features of the block walk. It may be noticed that the projecting edge of the continuous longitudinal joint has been chiselled down in an attempt to lessen the likelihood of a turned ankle. The defects shown could have been prevented by the use of a monolithic slab. Just how objectionable these defects are is made clear by all too frequent jury awards covering damage claims for injuries. Concrete in a walk on a residential street should give everlasting service, certainly for as long a time as the residences themselves. In the photograph it is seen that, though the walk should be replaced, the concrete itself is excellent. The marks of the corrugated roller have not been worn from the surface after 20 years' use and if separation into blocks had been precluded the walk today would have been as good as when laid.

It is often reported that sidewalks are pushed up by tree roots, but, in truth, Washington trees of approved species, as far as concrete walks are concerned, are wrongly abused in this respect. Brick walks offer little or no resistance to the lifting effect of roots and much damage is done. Concrete walks, even two course jointed ones, offer more resistance, and defects found in them due to tree roots are much in the minority. It is believed such trouble can be entirely eliminated by the adoption of the monolithic continuous slab.

Illustrating the faults of superficial observation, it is a usual assumption by the casual passerby that the curb stones shown in Fig. 2 have been pushed out of place by tree roots and statements to that effect are common. More close attention shows that the only curb out of line is that opposite concrete leads to houses. The subject of expansion and contraction of concrete is a fundamental element in a discussion whether of roads or walks. It is surprising that such a great degree of curb movement results from the expansion in but a 6 ft. length of lead while in other cases no movement results from stresses developed in long stretches of walk such as that fronting the steps in the photograph. Alternately expanding and contracting, the joints in the leads fill with dirt and the result is cumulative year after year. A total movement of as much as 3 in. in a curb opposite a 6 ft. length of lead has been recorded. Movement does not take place in a long stretch of walk because its own weight and friction on the soil sub base hold it in position. Similarly on streets of high class construction where the curb is rigidly held in place by the street pavement the concrete in the leads is confined and any condition tending to expansion but develops internal stresses without consequent curb movement.

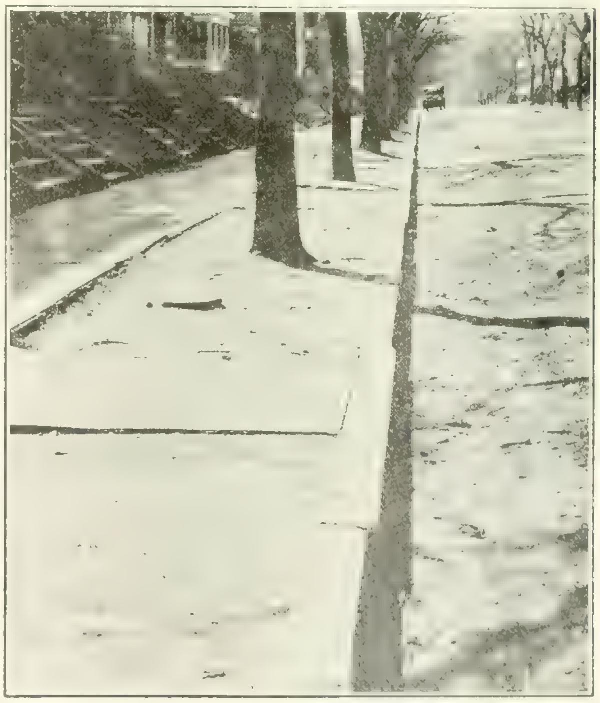

Fig. 2.—Walk laid in 1900. Curbs abutting leads pushed out of line; those opposite trees remaining true to line and grade.

In the District of Columbia two course sidewalks the 4 in. base is 1:2:5 concrete and the 1 in. topping is 1:1½ mortar and, therefore, division into small blocks is necessary. Otherwise, having a different expansive coefficient from the base and being laid in such a thin layer that it cannot take compression without buckling, the topping, at random cracks, separates from the base and pushes up like the gabled roof of a house. In order to overcome this tendency small blocks are made and projecting edges in due time appear for pedestrians to trip over, a fault that was particularly condemnable in flag walks. Even with division into blocks buckling of the topping is not entirely prevented and this notwithstanding most careful inspection during construction. Transverse mastic joints spaced at 30 or 40 ft. intervals are often advocated for the prevention of ill effects from expansion. Referring to Fig. 3 it is readily seen that the presence of expansion joints would not have prevented the defect shown in this photograph. The action that caused the buckling was entirely localized within an area 3 ft. square.

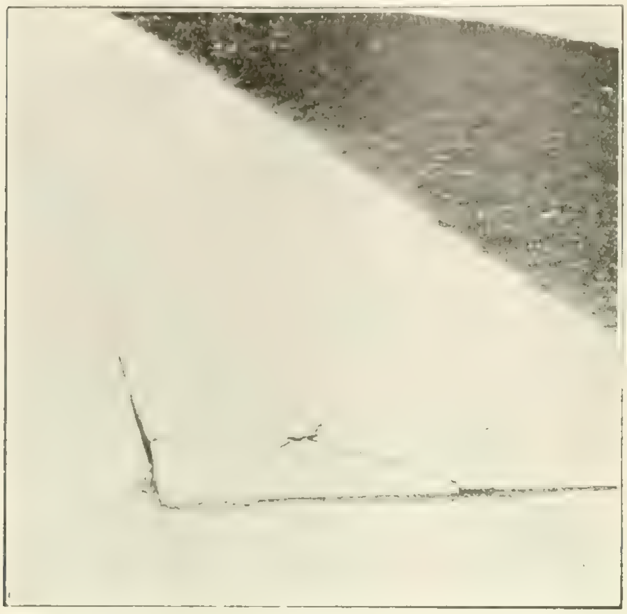

Fig. 3.—This area of two course walk was laid in 1919. The defect results from the separation of the topping from base, and, because of its thinness, it is unable to take compression without rupture.

Detrimental effects of compressive stresses developed in pavements due to the tendency of concrete to successively contract and expand are not directly proportional to the length of construction as is often supposed. If concrete is rigidly held in place and is of sufficient thickness to successfully take compression, no trouble ensues. Otherwise, objectionable movement occurs even in very short stretches; and buckling, though the slab area is a minimum.

In long continuous stretches of sidewalk the effect of longitudinal expansion is negligible, as has been stated, for the reason that the walk is held in position by its own weight and friction on the soil sub base. While this in universally true in the direction of length, it is not so crosswise of the walk in the case of two course ones jointed into small slabs. Transversally the weight and friction on the soil sub base not being sufficient for confinement a longitudinal opening appears sooner or later for the full length of the sidewalk as shown in Fig. 1. Injurious frost action is encouraged by the existence of such joints and the result is as illustrated in the photograph, the edge of one line of slabs showing above the abutting edge of the other line. While this is habitual to two course jointed pavement it is entirely eliminated in monolithic one course ones. Moreover the laying of leads integral with the walks, taken in conjunction with the elimination of the longitudinal joints, would do away with such large displacement of curbs as at present exists on macadam streets.

There are two main defects in two course construction, one being open longitudinal joints as just described; and the other, projecting edges at transverse joints as illustrated in Fig. 4. This latter is very objectionable and if permitted to exist soon leads to a damage suit in every case. The edge shown in the photograph is 1½ in. above the plane of the walk. The stresses leading to this displacement occurred entirely within a distance of 3 ft. of the joint, in the three blocks of concrete shown on the far side of the fault. No movement took place in the remainder of the walk.

Though joints in two course pavements are expected to preclude the development of cracks along other lines, random cracks do frequently appear. Examination shows that these are in the mortar topping only, seldom or never extending into the concrete base. In the lower central portion of Fig. 4 appears a random natural crack. The photograph aptly illustrates the degree to which joints in a walk may become a menace while natural cracks, though perhaps unsightly, remain otherwise inoffensive. Pedestrians pay little or no attention to the walk beneath them and, therefore, accidents are common when any unusual projection appears. The same disregard of underfoot conditions causes the existence of natural cracks to be but slightly observed. As for one course monolithic construction, since sidewalks are seldom more than 12 ft. wide, longitudinal cracks are of exceptional occurrence though transverse ones occur at more or less regular intervals. Where new work abuts old care must be exercised to have the faces of the resulting joint vertical and new concrete well tamped against old. Compressive stresses in a 5 in. slab of homogeneous construction bearing normally against another give no trouble at such a joint.

Not only does one course monolithic walk of rich concrete do away with those objectionable features of two course walk which at present prevent the attainment of full value from concrete, but a comparative test shows that there is marked economy in construction cost in favor of the one course walk. In order to first of all determine the practicability of constructing one course sidewalk several small jobs have been completed under various conditions. After this preliminary work two stretches of proposed sidewalk were selected, similar as to conditions in all respects, being located on opposite sides of the same street. These two jobs were carried out by the regular sidewalk contractor, one in accordance with his contract specifications for two course walk, the other under new specifications calling for one course of rich concrete. The favorable results obtained by the latter are the more remarkable when it is considered that a reorganization of the contractor's gang, which had been working like clock work day after day on a regular routine, was required in order to adapt it to new work as to the practicability of which the entire gang was skeptical.

In selecting the site for the test one was chosen that presented as difficult a situation as possible. Terraces and fences prevented the continuous screeding of the concrete as is usually done on road work with the strike board held to grade by the side forms or rails. Instead the walk had to be struck off from the houses toward the curb in patches 12 ft. long. Also there were tree pockets along the curb which interfered to some extent with the free use of the strike board. A comparison of the two types of sidewalk construction may be discussed under the heads: materials, concrete, mortar, and surface.

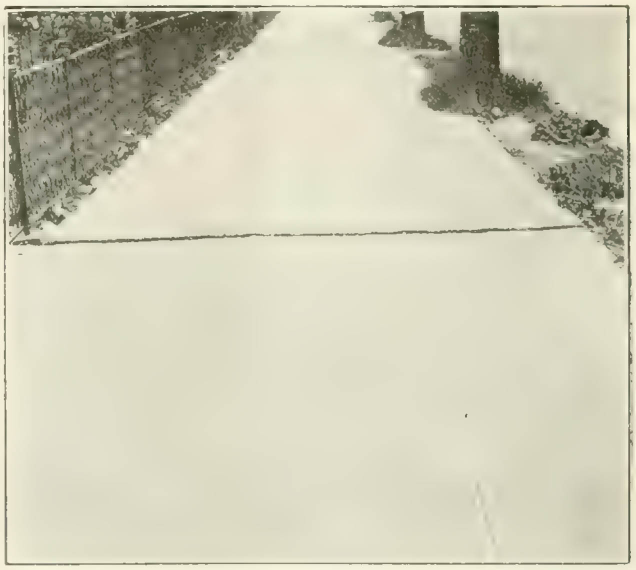

Fig. 4.—Walk laid July 1917. Shows that the projecting edge of the defective transverse joint is dangerous to pedestrians and that the natural crack which has occurred, through perhaps unsightly, is in no other way objectionable.

Materials: In the two course walk 361.4 sq. yd. were laid using a 4 in base proportioned 1:2:5 and a 1:1½ mortar topping 1 in. thick. In the one course walk 413.3 sq. yd. were laid 5 in. thick proportioned 1:2¼:3⅜. Each walk was dusted with a 1:1 dry coat. Data relative to the work may be tabulated as follows:

	Per 1,000 sq. yd.					
	One course			Two course		
	Cement, bags.	Sand, cu. yds	Gravel, cu. yds	Cement, bags.	Sand, cu. yds.	Gravel, cu. yds
Concrete	787	71	99.4	586	41	103
Mortar	...			453	30	
Dry coat	33.6	1.2		16.6	6	
Total	820.6	72.2	99.4	1,055.6	71.6	103

Thus in the two types of walk though there is insignificant difference as to the quantities of fine and coarse aggregate there is a saving of more than 200 bags of cement in each 1,000 sq. yd. of walk in favor of the one course.

The mixture used in the one course walk was 1:2¼:3⅜. In handling the aggregate 2¼ cu. ft. wheel barrows were used and the mixer charged with two bags of cement, two barrows of sand and three barrows of gravel for each batch. Though these proportions gave excellent results, the walk being floated to a finish fully as easily as one with a mortar topping, it is believed that for usual practice the sand and gravel should be slightly decreased and the cement increased about 100 bags per 1,000 sq. ft. This would give a ratio more nearly equal to what is commonly known as 1:2:3 and provide sufficient leeway to give proper workability of the concrete to insure good surfacing notwithstanding more or less rough wheel barrow measurement at the mixer and variation in Potomac aggregate grading. It is important to specify aggregate in terms of cubic feet per bag of cement and to insist that in case wheel barrows are used for mixer charging that they be of such size that the use of partially filled or heaped-up barrows shall be unnecessary. They should hold the exact required quantity when struck off flush with the sides by a board.

Concrete: The amount of gravel being only slightly greater for the two course walk than for the single course it was possible for the number of men charging the mixer with gravel to be the same for each type. One more man was required for sand on the one course walk than on the base of the two course, and the cement was handled by the same number in each case. Therefore it took but one more man to charge and operate the mixer for a course of 5 in. of concrete than for a base 4 in. thick of leaner concrete. Since gravel is the determining element governing the capacity of a mixer it was found that an area of one course walk 5 in. thick was laid at as fast a rate as the 4 in. base of the two course walk. This is shown in Fig. 5. Making allowance for mixer delays of one kind or another common to concrete work it is seen that the curve for the 5 in. walk practically coincides with that representing the 4 in. base, and this with but one more man in the mixer gang. Furthermore, it is seen that with the 8-hour law in force the mixer may operate later in the afternoon when a mortar gang is not interposed between the concrete and surfacing gangs. This permits the attainment of a greater daily yardage.

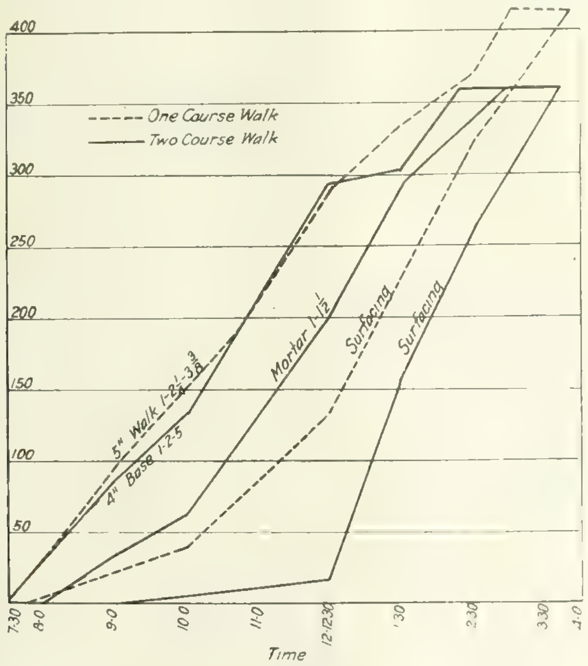

Fig. 5.

For the 4 in. base of the two course walk the concrete gang for spreading, making sand joints and tamping averaged seven men. For the one course work the gang on the walk consisted of eight men. This amply provided for using the strike board, spreading, rolling and such extra work as was needed around tree spaces and at the rear of the walk. The distribution is illustrated in Fig. 6. Concrete was placed in 12 ft. stretches. The strike board rode on a 1½ in. by 5 in. strip in the forward position and overlapped the previously laid concrete by about 1½ feet riding on this concrete as screed. The strike board man at this end stood on a 12 in. by 1 in. plank. With concrete mixed of the proper consistency the disturbance caused by this plank was negligible.

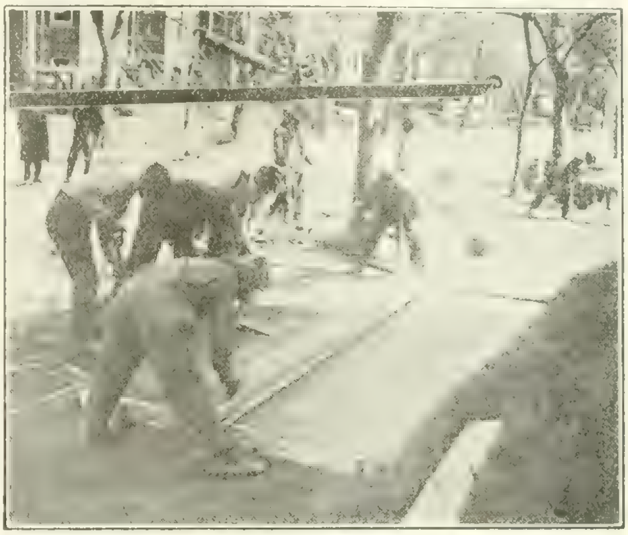

Fig. 6.—This shows the four details of one course walk construction after the concrete is deposited: Screeding, rolling, dry coat and marking and surface finishing.

The matter of consistency is of extreme importance as thereupon depends the success or failure of the type of one course walk described herein. The consistency was tested with a 12 in. cone having an 8 in. base and 4 in. top. It was found that with a slump of less than ¼ in. the concrete was so dry that the surfacing gang had difficulty in obtaining a good finish. With a slump of more than ¾ in. so much water came to the surface that the work of surfacing had to be delayed pending drying out. A slump between ¼ and ¾ in. gave good practicable results with sufficient latitude not to be bothersome in the adjustment of water on the mixer. It must be realized that this slump advocated pertains to the particular aggregate used on this job and that other aggregate might demand other regulation.

Mortar: The greatest economy in favor of the one course walk is in the elimination of the first cost and maintenance of a mixer, and in the labor cost of operating it and spreading the mortar. The labor for the 1 in. mortar topping approximated 3 men with the mixer, 2 delivering mortar and 3 spreading and screeding, a total of eight. In two course work with three major elements—concrete, mortar, and surface—carried along simultaneously, the number of men on each fluctuates from time to time during the day. It takes a good foreman and a well trained crew to develop a routine that will give the largest measure of success.

Surface: The surface appearance given the walks was identical, each being marked into 3 ft. square. The comparative test showed that the expenditure of time and labor in bringing them to a finish approximated the same for the two types, labor being somewhat more conveniently and economically distributed on one course walk. It can be seen from a study of Fig. 5 that during the forenoon very little surfacing was done on the two course walk and that during the afternoon, due to increasing the number of finishers the surfacing was speeded up. Such an arrangement was necessary due to the interposition of the mortar gang between the concrete and surfacing gangs. The surfacing curve for the one course walk, Fig. 5, also shows a lagging tendency during the forenoon. This was due to the fact that it was somewhat difficult for the organization to re[illegible] [illegible] and quickly adapt itself to the new [illegible].

It would have been entirely practical [illegible] walk to have started the dry coat [illegible] close behind the men rolling the concrete [illegible] them uniformly till the end of the day. With such an arrangement the surfacing curve, Fig. 5, would have been parallel to that representing the base and about 50 minutes (or 50 sq. yd.) behind it. The photograph, Fig. 6, shows the surfacing gang working at approximately this interval. First is the strike board gang working on a 12 ft. stretch. The next 12 ft. is occupied by the roller. Then two men, having dusted the dry coat on the following 12 ft., are lightly marking it into 3 ft. blocks in order that the finished walk may have the appearance of our heretofore constructed two course walks. Finally, on the fourth 12 ft. space are five finishers, each one kneeling on individual boards placed directly on the concrete.

To sum up: a 5 in. one course walk of gravel concrete, proportioned 1 bag of cement (one cu. ft.), 2¼ cu. ft. sand and 3⅜ cu. ft. gravel, presents all the advantages of a two course walk and none of its disadvantages. This is accomplished with (1) a saving of from 100 to 200 bags of cement per 1,000 sq. yd. of walk, (2) a labor saving of 6 men in an organization capable of approximating 350 to 400 sq. yd. of walk per day, (3) an increase, with a given type of concrete mixer, of from 10 to 12 per cent in daily yardage, and (4) a saving of the first cost and maintenance of a mortar mixer.

New Path Digging Loader Equipped With Creepers

A new Path Digging wagon loader equipped with creepers has been placed on the market by the George Haiss Mfg. Co., New York City. This new machine, the outcome of 12 months' study and test, is a stronger and heavier machine than the Haiss Path Digging loader equipped with wheels. The creepers, which are 8 ft. long overall and 6 ft. long centers, are cast steel 10 in. wide and of the self cleaning type. They overlap to prevent dirt and foreign matter from clogging the sprockets. The creepers are built of heavy steel castings and the frame support has a three point suspension. The motor is a 15 h.p. General Electric or Westinghouse and the engine is a Waukesha heavy tractor type developing 37 h.p. at 1,000 r.p.m. It is connected to the counter shaft by means of a Baldwin chain and through a gear which drives the elevator and also the wagon loader. The loader has a forward speed of 75 ft. a minute, a reverse speed of 45 ft. a minute and a crowding speed of 22 in. per minute. The head shaft is of heavy chrome nickel steel supported by steel takeup bearings which can be adjusted to take up the slack of the chain. This loader is also equipped with extra heavy buckets on which are installed saw tooth cutting edges. The rear tail shaft is 3 in. in diameter, squared to receive extra heavy steel lugs on which are bolted the heavy propellers. The overall height of the machine is 14 ft., with elevator collapsed it is 9 ft. The height under the chute is 8½ ft.

New Haiss Path Digging Wagon Loader

Resurfacing and Surface Treating Macadam Roads*

By T. J. WASSER,

President, Bates & Rogers Construction Co., Chicago.

To resurface or surface treat an old macadam road so that the maximum amount of service will be secured from the money expended is not an easy task. A macadam road may be suitable for a surface treatment yet wholly unfit to act as a foundation for a bituminous pavement. The ignoring of these differences has in the past, and is yet, causing the yearly loss of tremendous sums of money. The causes that produce these differences in macadam roads are fairly well known, yet the damage that these factors produce is seldom recognized. The fact that these old roads gave fairly good service as macadam roads is no proof of their suitability to act as a foundation for a bituminous pavement or surface coating.

Old Macadam as Base for Bituminous Pavement.—When an old macadam pavement is to be used as a future foundation for a bituminous pavement it should be studied during the critical time of the different seasons and all unstable, improperly drained or unsatisfactory places located and recorded. The depth of stone in the old pavement should be determined at frequent intervals, for it is often found that instead of having from 10 to 12 in. of stone, there is often not more than 3 or 4 in. The size of stone in the old pavement should also be noted, for it is frequently found that the base of those old macadam roads sometimes do not contain over 5 per cent of stone retained on a 2-in. screen. Stone of this kind is certainly too small for base purposes.

It is seldom that these old macadam pavements have the desired width. Additional width is often secured by excavating and constructing a new foundation on one or both sides of the old pavement. This method of securing additional width of foundation will not give the results expected unless the old macadam pavement is scarified to its entire depth, reshaped and the entire roadway, including the new foundation, rolled, until of the same density and stability. Unless this is done the old macadam pavement will be found to be much more rigid and stable than the new foundation. This difference in stability will cause a crack or break in the new surface pavement at the point where the two foundations meet.

The difference in width, depth of stone, character of stone, drainage and general conditions of old macadam roads makes it very difficult to prepare a set of specifications that will definitely define the quantity of each item of work to be performed when these roads are to be used as a future foundation for another type of pavement. In view of this fact, specifications should be so prepared and the various items of work so defined that they can be increased, decreased or omitted as occasion may demand, when the real conditions of the road are disclosed, during construction. Such a set of specifications naturally will differ greatly from those ordinarily used for new work, because in some places there may be no additional width or depth of foundation required, while in others half of the old pavement will have to be replaced with a new foundation or additional layers of stone added.

To meet these conditions it is desirable to secure bids whenever possible upon the unit quantity of materials being used, which should include all the work and equipment necessary to install these materials as required. Whenever an item is to be used in a fairly uniform quantity throughout the work, it can be specified in the usual manner. The following set of specifications is prepared along these lines and found to successfully convert an old macadam road into a fairly satisfactory bituminous pavement, and will, we believe, be found applicable to most of the old macadam roads.

Specifications for Converting Old Macadam Into Foundation for Bituminous.—In these specifications blank spaces are left for the insertion of other materials than those specified; also when reference is made to a particular requirement, the article and page should be inserted, for it is assumed that these specifications will be only part of a set which will contain all the other requirements governing the contract.

FOUNDATION TYPE REPAIRED MACADAM.

GENERAL.—The old macadam pavement when used as a foundation, shall be repaired, rebuilt and reconstructed in the manner given below. The location, length and width of the old pavement, crossroads, entrances or driveways to be repaired, rebuilt or reconstructed, or of new foundation required, shall be as designated on plans. The materials required therefor are given below.

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*[illegible] a paper presented [illegible] at the Highway Engineering Conference at the University of Pennsylvania.

PAYMENT.—This work will be paid for at the contract price per ton of stone as given in the proposal, which will include:

First. The cost of furnishing all labor, equipment, stone and binder needed to repair, rebuild or reconstruct the old macadam pavement as herein required.

Second. The cost of furnishing all labor, equipment, stone and binder needed to construct all new foundations and surfaces required.

Third. The cost of furnishing all labor, equipment, stone and binder needed to repair, rebuild or reconstruct all crossroads, entrances and driveways shown on plans to be repaired, rebuilt or reconstructed.

It does not, however, include the cost of scarifying, or the cost of making any necessary excavations or embankments for new foundation, sub-base material, street entrances, driveways, shoulders, gutters, curbs, underdrains or cross-drains.

Scarifying will be paid for by the square yard at the unit contract price as given in the proposal.

Excavation and embankment will be paid for at the unit contract price specified in the proposal.

MATERIALS REQUIRED.—The broken stone required for repairing, resurfacing, rebuilding or reconstructing the old macadam pavement, the new macadam foundation, or pavement on crossroads, entrances, or driveways, shall be 2½-in. stone prepared from trap rock, dolomite, or .... The binder used for this stone shall be screenings prepared from trap rock, dolomite, limestone, or ....

REPAIRING OLD PAVEMENT.—Before the old pavement is scarified, all places showing evidence of instability, or improper drainage, shall be repaired as specified. The old foundation shall then be replaced with the addition of sufficient new stone to fill the opening so that the same will be even with the adjacent foundation after compression. This stone shall then be rolled sufficient to insure that it has the required stability, and is at the required grade.

The excavation for all new foundation required shall be made and the same constructed as specified below before the old macadam pavement has been scarified.

When the old foundation at the edges is not of the proper character or thickness it shall be excavated and the excavation carried toward the center of the roadway until a good stone shoulder is exposed having the required depth and stability. All new foundation thus required that is not shown on plans shall be designated or located by the engineer and constructed as herein provided for a new macadam foundation.

CONSTRUCTING NEW FOUNDATION.—The 2½-in. stone shall be deposited upon the subgrade in a uniform layer for the depth and width shown on plans. It may be spread directly from vehicles approved for this purpose. If dumped on the subgrade, it must not be deposited within the area over which it will be spread. The thickness of this course of stone shall be measured by wooden blocks of the required thickness placed among the stone when so ordered by the engineer. No stone shall be spread upon a wet subgrade nor more than sufficient stone for an average day's work shall be spread in advance of rolling and filling neither shall stone be placed adjacent to structures or railroad tracks until they have been set to the required grade and alignment.

As soon as this course of stone has been properly spread it shall be rolled with a 3-wheel power roller, weighing not less than 10 tons, until thoroughly consolidated and compacted to an even, smooth surface. During the initial rolling the roller shall travel parallel to the axis of the pavement. Subsequent rolling shall be both diagonal and parallel to the axis of the pavement. The rolling must be so executed that every part of the stone surface receives compression from the rear wheels of the roller.

After the stone has been properly rolled there shall be spread over its surface and worked into the voids thereof one of the binders above specified. This binder shall be applied in thin layers with intermittent rolling between each application. The binder shall not be rolled until it is dry. The application of binder with intermittent rolling shall continue until all voids in the stone have been filled, the stone ceases to creep or sink under the roller and is at the proper grade. If the binder forms a cake or layer on top of the stone during rolling and does not work into the voids properly it shall be broomed or swept into the voids. The binder, however, shall not be applied in sufficient quantity to completely cover or form a layer or coating of this stone. When so applied the excess binder must be removed. The binder must not be dumped on the subgrade or upon unbound stone. Before and until the surface pavement is applied on this foundation it must be firmly bound together, be at the proper grade, have the required crown, be free from ruts, loose stone or places showing evidence of instability and stone covered with sufficient binder as to hide the top faces and edges.

SCARIFYING.—After the old macadam pavement has been repaired as above specified and all new foundation required has been constructed, the surface of the old pavement shall be scarified sufficient to loosen the original pavement. At places where the original pavement has been worn away, exposing the foundation of macadam or telford, care must be exercised during scarifying not to disturb the old foundation at such points. The road surface shall then be reshaped by distributing the old material evenly over the surface of both the old pavement and the new foundation, so that, after being thoroughly consolidated by rolling, the surface thereof will be at the grade and have the crown shown on plans.

SPREADING NEW STONE.—There shall then be spread over the entire surface of all new, reconstructed and repaired foundations, a uniform layer of new 2½-in. stone.

The thickness of this layer of stone shall be sufficient that after ultimate compression it shall have the depth shown on plans. After it has been spread it shall be rolled with a 3-wheel power roller, weighing not less than 10 tons, until thoroughly consolidated and compacted to an even, smooth surface. During the initial rolling the roller shall travel parallel to the axis of the pavement, beginning at each edge and working towards the center. Subsequent rolling shall be both diagonal and parallel to the axis of the pavement. The rolling must be so executed that every part of the stone surface receives compression from the rear wheels of the roller.

APPLICATION OF BINDER.—After the stone has been properly rolled there shall be spread over its surface and worked into the voids thereof one of the binders above specified. This binder shall be applied in thin layers with intermittent rolling between each application. The binder shall not be rolled until it is dry. The application of binder with intermittent rolling shall continue until all the voids have been filled and the stone ceases to creep or sink under the roller and is at the proper grade. If the binder forms a cake or layer on top of the stone during rolling and does not work into the voids properly it shall be broomed or swept into the voids. The binder, however, shall not be applied in such a quantity as to completely cover or form a layer or coating on this stone. When so applied the excess binder must be removed. The binder must not be dumped on the unrolled foundation stone.

After this layer of stone has been bound and consolidated, as above specified, and complies with the other requirements given therefor, the road shall be open to travel for a period of 5 to 15 days, or as much longer as the travel will require, in the opinion of the engineer, to give the pavement the additional compression desired, to remove from its surface all loose and surplus material, and to leave the surface of the stone projecting through the binding matrix with the top edges of the surface clean and free from all dust, dirt or other foreign material. During this period all material removed by traffic from the center of the pavement and deposited on the edges shall be swept towards the center of the pavement until such time as the surfaces and edges of the stone are uniformly cleaned and exposed for the full width of the pavement. The contractor must repair at once any places that become loose, raveled or rutted. The stone shall be re-rolled and re-bound in the same manner as specified above unless ordered otherwise by the engineer. Before and until any surfacing material is deposited on this stone, it must be firmly bound together, be at the specified grade, have the required crown, and be free from ruts, loose stone, or stone coated with binder or dirt, and stone covered with sufficient binder as to cover the top faces and edges thereof.

If at any time during the construction of the surface the subgrade shows evidence of instability, is forced below grade, or up into the voids of the stone, the contractor shall, without additional compensation, dig out all such loose or unstable material, reshape and repack the subgrade in the manner ordered by the engineer and replace the stone removed with the necessary additional stone which, when bound and rolled as herein specified, shall give the required stability.

Resurfacing Macadam with Bituminous Dressing.—The mileage of macadam roads, which have been resurfaced with a bituminous dressing, is certainly very large. The initial cost of such a treatment is usually very low, which makes this method rather popular, yet if we judge the merits of this method by the results which have been achieved in many localities, it certainly cannot be recommended as being very efficient or satisfactory. However, in certain localities, very satisfactory results have been secured by this method. The reason for the differences between the results secured can usually be traced directly to the character of the aggregate and the sub-base conditions of the roads thus treated.

In many localities, it has been the practice to repair these roads with the addition of ¾-in. stone and screenings. These materials have been scattered over the surface of the road for years and generally the inequalities in the road surface are removed by the addition of such stone just before a surface application of bitumen is applied. In general, the surface of those old roads is composed of stone from 1 in. in diameter down to dust and it is not surprising that a bituminous dressing will not properly adhere to such a surface. Stones of this size are not very firmly anchored into the road-bed and are easily knocked out by traffic or in the cleaning of the surface durin[illegible] It is very difficult to properly clean such a surface and, unless the surface stones are clean, the bituminous material applied will not properly adhere.

It is not uncommon to find stretches of bituminous coated roads where the dressing has broken loose and disappeared. Holes are quickly formed in such exposed surfaces which make a road nearly impassable for auto traffic. Roads of this type are not uncommon and, as previously stated, this method of maintaining a macadam road has not given the satisfaction expected.

Again, we find, in order to true up the ruts and depressions in a macadam surface which has not previously been treated with a bituminous material, that sufficient bitumen is added to form a bituminous coating from ½ in. to 1 in. in thickness. Bituminous coatings of this kind are prone to creep and become bumpy unless the aggregate used in absorbing the bitumen is composed of stone from ½ in. to 1 in. in diameter. One-quarter inch stone, pebbles or coarse sand does not usually possess sufficient stability to prevent a layer of this thickness from creeping since the bituminous material is usually very soft and possesses very little stability within itself. It is false economy to cover these old roads with a bituminous coating of this thickness for, as a general rule, the thinner the layer that can be held in place, the better results will be secured.

If the maximum amount of service is to be expected of these bituminous coatings, the surface upon which they are to be applied must be free of all material that will prevent the bitumen from properly adhering to the stone surface. This makes it almost mandatory that the stones in the surface be of sufficient size to be firmly anchored in place so that they may be cleaned by traffic or sweeping without danger of raveling the road surface. It is seldom that we find the surface of an old macadam road composed of stones that are of the proper size to permit being satisfactorily cleaned.

Usually a surface to be given a bituminous dressing is more or less raveled and full of holes. Such a surface should always be scarified and covered with a layer of stone. The size of this stone should be sufficient to permit of its being properly bound and cleaned without raveling. Two and one-half inch stone has been found to be the size best adapted for this purpose and this stone should be fairly uniform in size and free from the smaller sizes. Such a stone will make a more uniform pavement surface and the individual stones in the surface layer will be held more firmly in place than if the stone were run of the crusher from this size down to ¾ in. stone. Very satisfactory results have been secured by re-dressing old macadam roads with stone of this size and then resurfacing with a bituminous material. The initial cost of such a treatment is naturally somewhat more than if the holes were simply repaired with ¾-in. stone and the surface then given a bituminous coating. Yet while the former method may be somewhat more costly than the latter, it puts the macadam road in shape so that it can be constantly maintained at a reduced cost. The latter method of treatment cannot be considered as any permanent improvement to the macadam surface and each year it will be found more difficult and expensive to maintain the surface than previously, for the failures will become more pronounced and the chances of the surface creeping and becoming bumpy is also increased.

Specifications for Surface Coating for Macadam Roads.—The method recommended to be followed in the surface coating for a macadam road by the addition of a new layer of stone is that given in the specifications below. It should also be noted that all the materials required to be used are not specified, but blank spaces left in which any of the various materials, which have been used for this purpose, may be inserted. It is assumed that these specifications will be only part of a set which will contain all the other requirements governing the contract. When it is thought necessary to refer to a definite page and article defining the requirements of any materials or equipment to be used, these pages and articles should be inserted.

[illegible]

[illegible]

[illegible] from trap rock, dolomite or . ... These materials shall comply with the requirements given herein.

Scarifying. The entire surface of the old macadam pavement shall be scarified. The depth to which scarifying shall extend shall not be sufficient to loosen or disturb the old foundation. After scarifying the surface material shall be so distributed that all inequalities in the contour and composition of the surface shall be eliminated. The re-shaped surface shall then be rolled just sufficient to anchor the stone into place and true up the surface.

Spreading Stone.—The 2½-in. stone shall be deposited upon the foundation in a uniform layer of such depth that after ultimate compression it shall have the depth and width shown on plans and weigh not less than 75 lb. per square yard for each inch of depth exclusive of binder. It may be spread directly from vehicles approved for this purpose. If dumped on the foundation, it must not be deposited within the area over which it will be spread. When so ordered by the engineer the thickness of this course of stone shall be measured by wooden blocks of the required depth placed on the foundation. No stone shall be placed upon a wet foundation nor more than sufficient stone for an average day's work shall be spread in advance of rolling and filling.

Rolling.—As soon as this course of stone has been properly spread it shall be rolled with a three-wheel power driven roller weighing not less than 10 tons until thoroughly consolidated and compacted to an even, smooth surface. During the initial rolling the roller shall travel parallel to the axis of the pavement, beginning at each edge and working towards the center. Subsequent rolling shall be both diagonal and parallel to the axis of the pavement. The rolling must be so executed that every part of the stone surface receives compression from the rear wheels of the roller.

Application of Binder.—After the stone has been properly rolled there shall be spread over its surface and worked into the voids thereof one of the binders above specified. This binder shall be applied in thin layers with intermittent rolling between each application. The binder shall not be rolled until it is dry. The application of binder with intermittent rolling shall continue until all the voids have been filled and the stone ceases to creep or sink under the roller and is at the proper grade. If the binder forms a cake or layer on top of the stone during rolling and does not work into the voids properly it shall be broomed or swept into the voids when so ordered by the engineer. The binder, however, shall not be applied in sufficient quantity to completely cover or form a layer or coating on this stone. When so applied the excess binder must be removed. The binder must not be dumped on the unbound stone.

After this layer of stone has been bound and consolidated, as above specified and complies with the other requirements given therefor, the road shall be open to travel for a period of ...... to ...... days, or as much longer as the travel will require, in the opinion of the engineer, to give the pavement the additional compression desired, remove from its surface all loose and surplus material and leave the surface of the stone projecting through the binding matrix with the top edges of the surface clean and free from all dust, dirt or other foreign material. During this period all material removed by traffic from the center of the pavement and deposited on the edges shall be swept towards the center of the pavement until such time as the surface and edges of the stone are uniformly cleaned and exposed for the full width of the pavement; also, the contractor must repair at once any places that become loose, raveled or rutted. The stone shall be re-rolled and re-bound in the same manner as specified above unless ordered otherwise by the engineer. Before and until any surfacing material is deposited on this stone it must be firmly bound together, be at the specified grade, have the required crown, be free from ruts, loose stone or stone coated with binder, or dirt or stone containing sufficient binder to cover the top faces and edges thereof; also, must be free from places showing evidence of instability, improperly consolidated or bound stone.

As soon as the road surface is in condition as above specified it shall be coated immediately with an application of asphaltic oil, Grade ...... This oil shall be uniformly applied over the surface of the stone at the rate of ...... gallons per square yard of surface coated from a pressure distributor which has been previously approved by the engineer for this purpose. The oil shall only be applied during warm, clear weather and the stone must be dry when application is made. The road need not be closed to travel unless the engineer so directs.

As soon as the oil applied has penetrated into the road surface and cured, sufficient to hold the fine mineral matrix in place and settle all dust, the surface shall be immediately coated with an application of asphaltic oil grade ...... It shall be applied at the rate of ...... gallons per square yard of surface coated in the same manner as specified above. The application of this second oil coating must be made before travel has started to loosen the stone or ravel its surface. Immediately after this oil coating has been applied it shall be covered at once with a coating of dustless screenings or ¾-in. stone, as may be directed by the engineer. This stone shall be applied in sufficient quantity to completely cover the bituminous binder applied. It shall be rolled immediately and, as soon as the rolling is completed, the road may be opened to travel. During rolling or any time previous to the final acceptance of the work, if bituminous material appears on the surface of the road, additional dustless screenings shall be applied at the time and in the manner required by the engineer. If the contractor fails to make such repairs within 10 days after being directed to do so by the engineer, said repairs may be made by the Department and the cost thereof shall be deducted from any money or moneys due the contractor.

The contractor shall leave at frequent intervals along the roadway, as directed by the engineer, piles of dustless screenings to make repairs in the manner above specified.

A Plain Statement of the Need of Better Pay for Engineering Service

Some weeks ago Mr. A. R. Hirst, State Highway Engineer of Wisconsin, tendered his resignation. His reasons for taking this step were set forth in a statement given out by him at the time. This statement voices so clearly the views of many other engineers, that we are reprinting it below in full:

The filing of my resignation as state highway engineer, effective not later than Dec. 31 of this year, or earlier, at the pleasure of the State Highway Commission, has occasioned considerable comment and some speculation as to my reasons for taking the step, especially in view of the fact that the present salary attached to the position, $7,500 per annum, is one of the largest paid in the state service. It is only fair to those people of the state who have so loyally and freely supported our efforts for the betterment of highways in Wisconsin that I should at this time give some of the reasons for taking the step which has been announced.

I wish to state at the outset that there is and has been nothing in my relations with the State Highway Commission, with any past or present state official, or with the present legislature, to impel me to resign. My personal and business relations with all of these persons and bodies have been of the pleasantest, and, I have every reason to believe, would so continue as long as I felt able to remain in the state service.

Wisconsin's Accomplishments in Highway Building.—It is nearly 14 years since I entered the highway service of Wisconsin. In that time, under the impetus of the state-aid and federal-aid highway laws, the highway program in Wisconsin has reached tremendous proportions. There have been built 8,500 miles of all types of highway and 1,700 bridges at a total cost of $40,000,000. For the planning and execution of this work, I, as the chief engineer and executive officer of the State Highway Commission, have been personally responsible.

For 1921 there is available a total of over $20,000,000 for federal, state and county-aid construction of roads and bridges in Wisconsin, exclusive of the amounts available for strictly town, village and city construction. This sum will not and should not all be spent, because we are not organized to spend it properly, but probably well over 2,000 miles of all types of highway will be built. The years that have gone since 1907 have seen Wisconsin placed in the foremost rank as a state which is building roads as fast as sound business judgment warrants, and as a state which, in the meanwhile, has maintained a highway system of which most of her citizens are proud.

I give these matters of record, not in a spirit of boastfulness, but simply in order that something of the magnitude of this great enterprise may be realized. In these accomplishments, through nearly 14 years of service I have played my part. I am proud to have been connected with the state and with its highway work. The fact that no shadow of suspicion of crookedness or graft has ever fallen on any part of this great expenditure will always be one of my proudest memories.

Public Opinion of Value of Public Service.—I have been content to serve because I loved the work and it was my one ambition to help to give Wisconsin a system of highways worthy, if possible, of the state and of its citizenry. It has not been profitable work, in terms of money; it has been hard work and, at times, extremely trying. Nevertheless, I should gladly have continued for the rest of my active life had I felt reasonable assurance that public sentiment would support the legislature, the highway commisison and the county boards in the payment of salaries adequate to maintain organizations of the proper capacity to handle with efficiency the tremendous expenditures ahead.

Salary has been considered the only unimportant part of public office. Given any salary, and place could be filled. There would be hundreds of applicants for the position of state highway engineer if the salary were $2,500 instead of $7,500 per annum. As long as the public is willing to accept any kind of service, it can fill all of its places at any given salary.

As examples of public opinion of the value of public service, Wisconsin pays its Governor $5,000 a year, its secretary of state, its treasurer, and its attorney general the same amount. She pays the members of her legislature $500 for two years' service, not enough to pay their board in Madison and their railroad fares to and from Madison, while they spend at least six months in the state's service away from their business, homes and families.

All of these places and many hundreds of other elective positions in state, county and all other units of government, are and will always be filled and generally well filled, because the honor, prestige and experience are worth a personal sacrifice for a limited period. However, few of these offices are the life work of the incumbent. They are either stepping stones to other things, or are the contribution to the public welfare of men who have made their stake and can afford the sacrifice. The expediency of this public policy for even this type of public service is a grave question.

Public Must Pay the Market Price.—Certainly, a business undertaking of the first magnitude, such as is Wisconsin's program of highway construction, cannot be picked up and laid down by any citizen, or group of citizens, at will. It is worthy of, and must have, the service of a high class, continuing organization of the best business brains and the best engineering and administrative talent that the market affords, if the state and the counties are to expend to advantage the millions which are available and which will continue to be available for all the years to come. Hundreds of dollars can be saved or wasted at every step and millions can be made or lost by a mistaken state-wide construction or administrative policy.

A proper organization to control this kind of construction enterprise cannot be political; it cannot suffer too great annual changes in personnel. It must be an organization able to meet on an even footing of brains, training and experience, the best organizations that the manufacturers of road machinery and materials can buy. It must be able to stand knee to knee with the best and worst contractors and get for its clients, the people of Wisconsin, good construction at a fair price. The public must equip itself with eminently fitted representatives in this struggle, or the losses in poor roads and unjustified prices will be appalling.

I had hoped to build up such an organization for Wisconsin. Until the public mind grasps the situation and supports a proper scale of salaries in the public service I am convinced that I cannot succeed. As fast as we train men, the best are picked for service in the commercial field. In 1920 the commission lost 27 per cent of its principal employes, and indications are that the losses in 1921 will be even greater. This will continue to be the case until the public realizes that it must protect itself by paying more nearly the market price for highway training, business experience, brains and energy.

The situation facing the state highway organizations is serious, but the situation in the county highway organizations is infinitely worse. The salary paid the county highway commissioner in most of the counties does not attract, or if it does attract, cannot long hold in the service the type of men who should and must fill these important executive positions. In a large fraction of the counties the clerical organizations charged with the accounting for expenditures often reaching into the hundreds of thousands of dollars is not as adequate as would be required to operate properly a not too busy corner grocery store. Despite all that the commission has preached and sought to teach, the last few years have seen but little improvement in the average standard of the county organizations, while the expenditures have mounted apace.

The Mole Hill of Public Service Expenditures and the Mountain of Public Waste.—There is little that I can sense in the present public attitude toward public service to make it possible to hope for any great improvement in the situation. Petty savings to be made by reducing the compensation of already and always underpaid public servants are dragged forth constantly in all units of government as the panacea for all tax evils. Waste at the bunghole is lost sight of, while a pin prick through the head of the barrel is magnified into a geyser. The people cry for efficiency in public expenditures and then strangle it, still-born, by ill conceived and shortsighted financing of the supervision of those expenditures. It seems impossible to make the people, as a whole, realize that if the entire expense of all national, state, county and local legislative, executive and clerical staffs were eliminated from their tax bills, they would sense no appreciable difference in their individual taxes. So much attention has been centered on the mole hill of public service expenditures that little regard has been paid to the mountain of public waste resulting from inadequate and ill-paid staffs of public servants.

The consequences of this general public attitude is not so serious when only routine clerical public business is concerned, but when the states come into contact with an open competitive market for skilled service in a great construction enterprise, where the public buys hundreds of millions of dollars worth of machinery, materials, roads, and bridges from corporations, firms, and individuals who equip themselves with the best brains and experience that the market affords, the only possible ultimate result is disaster to the public and to the public purse.

As I look into the probable future, I am unwilling to continue to take the responsibility for the proper expenditure of the tremendous funds now available longer than is necessary for the State Highway Commisison and the state chief engineer to select my successor. I shall relinquish the work with the most profound regret. One does not easily surrender an almost lifetime ambition unfulfilled.

The Public's Highway Organization Must Be Put on a Business Basis.—However, until there is a general public awakening, it must be obvious that the financial measurement by the public of the value of my services must va [illegible] the value of these services to myself and family in the commercial field, that no other course is open for me. If, by continuing my connection with the work, I could prevent the coming distaster, it would be my duty to stay. But I, or no other one man, can stem the tide. The public must sense the danger and urge its representatives to act, if any worth while action is to be secured.

If the whole public service cannot be properly organized, at least the public's highway organization must be put on a business basis. I cannot afford to be longer connected with it unless it is so put. Lacking that basis, both the elements of personal progress and the element of protecting my reputation as a highway engineer must impel the relinquishment of a position both unprofitable and fraught with danger to my future career.

It may naturally be said, "Is this not a cry of wolf, wolf? Wisconsin has done pretty well and is recognized as one of the leading states in highway construction and maintenance. There is no reason why it should not continue to do so. Hirst is an alarmist."

It is true that Wisconsin has done pretty well. The results have been probably 75 per cent of what they could have been made with adequate public support. Wisconsin and her counties have been lucky and have gotten better service than they paid for. But we are entering a new era. The expenditures of past years are as nothing compared to those proposed for the years to come. The competition for brains and experience of superior value in planning and building highways and for talent in all the fields allied to unless her counties act, the price of self-satisfaction will be exacted. This is not a cry of "wolf, wolf"—it is the expression of a mathematical certainty.

Modified Road Construction Contract for Present Conditions

A new form of contract for highway construction designed to protect both the contractor and the state, has been worked out by Mr. W. R. Neel, State Highway Engineer of Georgia. The form was described by Mr. Neel in a paper presented Dec. 14 at the annual meeting of the American Association of State Highway Officials. The paper follows:

In presenting for the consideration of this association a new form of contract, I wish to remove from the minds of everyone any suggestion or thought that I have devised a form of "cost plus" under a new name. However, the "cost-plus" contract, when originally drawn, embodied two fundamental principles, namely, fairness to everyone.

First, that the owner or beneficiary should pay the cost of the improvement. Second, that the contractor effecting the improvement should be fairly compensated for his efforts. Recognizing these two principles, then, we have had as a result several forms of contracts based on these fundamentals. The cost, with a percentage of whatever that cost might be to cover the compensation, commonly known as the "cost plus," is in bad repute, and certainly the results of the use of this method during the late war have given everyone just cause for prejudice against it. In an effort to remove the incentive to an unscrupulous contractor to increase the cost, thereby increasing his profit, the cost, plus a fixed fee, was tried out and proved more satisfactory to the owner and also the conscientious contractor.

My principal criticism of the cost plus a fixed fee is that there is no incentive for the contractor to keep down the cost of the work other than a desire to secure a reputation for economical and efficient work. In public work, where it is necessary to advertise and receive bids, thereby removing to a great extent the discretionary powers of the public official in selecting the contractor, something more than the two above-mentioned forms of contract are needed. In attempting to embody the two fundamental principles recognized by everyone as a basis for any contract, and at the same time perfect a contract more adapted to the execution of public work, the Form "B" Contract was written.

The original draft was submitted to a large number of people, such as experienced engineers and contractors, as well as legal talent of varied ability, and changed to meet those suggestions we thought worthy of consideration.

Since initiating work under this form of contract other changes have been made to perfect its weak points, and I wish you to understand that in submitting this to you I am cognizant of the fact that it will probably be changed from time to time as experience in its use directs.

Reasons for New Form of Contract.—In approaching the demand for a new form of contract in Georgia I was confronted with a constantly ascending scale of unit prices, each succeeding set of bids being a little higher than those preceding, until it was a question of either suspending the letting of new contracts or of devising a means of decreasing the cost of the work. I do not wish to place all the blame for the excessively high bidding upon the contractors; they, in turn, were under the fear and actual conditions of constantly ascending prices for material and labor, together with the uncertainty of freight rates, until no one knew where he stood nor how to bid. It was a gamble, as the old form of contract always has been, with the odds heavily against the contractor, and, as a consequence, the high bidding Furthermore, everyone was affected by the many uncertainties, and the bonding companies, realizing the greater risk, demanded of the contractor higher bidding. On several occasions contractors have informed me, after the bids had been rejected, that they were willing to submit a lower bid, but could not secure a bond if they did so.

It therefore appeared to me that, in order to meet this situation, it would be necessary for the state of Georgia to carry a large part of the risk, and, briefly, the actual use of the present form of contract immediately produced the desired results in deceasing the cost of the work to the state.

Some Features of the New Contract.—The use of this form of contract does not eliminate competition. The contractor, in submitting his bid, divides it into two parts—the estimated cost and the desired compensation. In order to have an incentive to keep down the cost, the contractor is allowed 25 per cent of any saving on the estimated cost, providing it does not exceed 50 per cent of the total compensation in the proposal, and should the cost exceed the estimate, 50 per cent of this excess is deducted from the compensation, with the provision that the compensation must not be reduced more than 75 per cent. Therefore, the contractor is assured of at least 25 per cent of the compensation, as shown in his bid, for which he must furnish at his expense a superintendent and any overhead expense, such as the maintenance of his general office. It is calculated that the 25 per cent will allow the contractor to break even, with no loss other than that of his time. The contract also provides for a machinery and equipment rental, a form being provided which must be filled out and which forms a part of the contract cost of work. However, the rental schedule is fixed, and only the interest on the value of the equipment is allowed, plus a fair compensation for depreciation, insurance and estimated repairs. In this way no profit can be made other than that shown as compensation, and this amount varies with the skill and zeal used in prosecution of the work. Thus the minimum compensation obtainable by the contractor will be 25 per cent of the compensation shown in the bid, and the maximum will be the compensation shown in the bid, plus an additional 50 per cent of this amount. If the contractor should be so fortunate, the owner should not begrudge him this additional compensation, as additional compensation means a saving of 75 per cent to the owner.

The cost of the work is paid by the owner, who is required to pay promptly all bills in order to take advantage of any cash discounts. A bonded accountant in the employ of the owner makes up payrolls and supervises the paying of all labor, etc. All materials are purchased by the purchasing agent of the state highways department, and the prices for all materials f.o.b. railroad siding are included in the proposal. In this way the only financing required by the contractor is in purchasing of equipment pertaining to the job and in paying the salary of his superintendent. This has resulted in the immediate delivery of all necessary materials for the vigorous prosecution of the work as soon as practicable after the awarding of the contract.

The contractor is called upon to furnish the necessary equipment, and a skilled organization properly directed by an experienced and efficient superintendent. The elimination from the requirements of the contractors of practically all financing results in a considerable reduction in the compensation demanded by them, so that is practically net profit to the state under this form of contractor.

At first thought it might appear that the compensation of a contractor could be saved by an organization operated by the highway department, but analysis makes it evident that the item of compensation of a contractor, if conservative, would closely correspond to the operating expenses of an organization owned by the highway department, and, while it should not be the case, I am afraid in actual practice it would be hard to get supervision for a state contract in an organization working on salary that would exert the same effort in construction as would a contractor under the Form "B" contract, where incentive in dollars and cents would be to keep the construction cost under the estimate. At the same time, the estimate must be conservative in order to meet the competitive feature.

In addition to this objection to a state construction organization, there would be the enormous investment in equipment which could only be used on state highway work, whereas a contractor has for a field not only state highways within the state, but in other states, as well as municipal, railroad work, etc.

Results Obtained Under New Contract.—One of the first advantages of this new form of contract is that it permits honest contractors of small means to show their ability on a larger scale than would be possible under the old form under which a surety bond is required for the full amount of the contract, which many contractors of small means are unable to make. At the same time, the facilities of financing this Form "B" contract open a field for intelligent, honest bidders who would otherwise be unable to participate in a project of very great magnitude, except as subcontractors, although their ability might be ample to handle the project. A striking example of this is a recently completed concrete paving project. The successful bidders could not have financed a project of this extent under the old form of contract, and yet they have had charge of the construction of more miles of concrete pavement within the state than any other contractor.

The result has been that 5½ miles of 18-ft. concrete pavement were laid in 3¼ months at a 15 per cent net saving on the contract as awarded. The contractors not only earned their compensation as set forth in their bid, but an additional 50 per cent, the maximum amount permissible. The advertisement for the letting of this contract, as is our custom, called for bids under both forms of contract. The successful bid was on Form "B," and was 24 per cent less than the next lowest bid, which was on the old form of contract, and it therefore resulted in an actual net saving of practically 30 per cent under the Form "B" as against the standard form of contract.

Project 1-A—F-2 concrete pavement is showing a saving of 11.3 per cent on first estimate.

F. A. Project No. 162, a grading job, shows a saving of 13.2 per cent, and the work has been under way for more than three months.

The contracts now under way in Georgia under the Form "B" amount to over $1,500,000, and a saving of a little over $20,000 has been effected in bond premiums alone, as a minimum bond is required under this form of contract.

The supervision that is required under the Form "B" contract by the owner requires a very high-class man, preferably one with experience as an inspector on the old form contract, and also experience as a contractor or superintendent for a contractor. His duties are to watch for violations of the contract and to catch the leakages on the job. The former duty should be performed subconsciously, but most of his thoughts should be centered on methods to reduce the cost. The cost sheet tells him a very true story, and should be kept up to date, so that he can see at a glance where he should put most of his attention.

I will conclude by stating that, in my judgment, this form of contract requires a more intelligent insight into construction details and a more thorough knowledge and analysis of costs by the engineer than the old form.

Increased Interest to Be Paid on Pennsylvania Road Bonds.—Governor Sproul of Pennsylvania has signed the Eyre bill, authorizing the replacement of the $11,800,000 short term road bonds issued early last spring to a syndicate of bankers when no buyers could be found at the 4½ per cent interest rate paid by the state, by bonds of a longer term and higher interest The bill provides the replacement bonds shall be at the interest rate for which the bond issues to be sold in July are offered and that any premium paid on the new bonds is to be taken into consideration in the replacement of the short-term bonds.

$1,000,000,000 of Highway Bonds Authorized.—State and county highway bond issues aggregating $998,953,000 were authorized from Jan. 1, 1919, to Dec. 31, 1920, according to statistics collected by the Portland Cement Association. Of the above total, $594,132,000 was authorized to Dec. 31, 1919, and the remainder authorized in 1920.

Contractor's Organization and Planning for Asphalt Paving Jobs

Useful suggestions on the above subjects, based on experiences and observations of the past 15 years in highway work, are given by Mr. Henry B. Drowne, Division Engineer of the Lane Construction Corp., Meriden, Conn., in a brochure, "Suggestions for Asphalt Paving Contractors," prepared for and published by The Asphalt Association. From advance proofs of the brochure we take the matter that follows:

Some jobs will not move right and ultimately may show a loss in spite of the fact that the contractor has everything in the way of plant equipment, ample resources, and fair prices on the work. In such an instance lack of success can probably be laid to poor organization as much as anytthing else.

The Value of a Good Superintendent.—A good superintendent on the job is a prerequisite and many contractors who undertake to superintend their own jobs make a miserable failure of it. The contractor is obliged to leave a good deal of the detail of construction to his superintendent. Contingencies will arise that require a modification or change of any prearranged plan, and the superintendent must adopt such a change on his own responsibility. As a superintendent is continually coming in contact with the residents in the neighborhood of the job, it is worth a good deal if he is a man of diplomatic trend. If he hasn't such a trait, the contractor can well afford to spend some time in trying to impress him with its importance. The tactful superintendent is often able to make arrangements for materials or set ups that save money, while the superintendent who possesses the faculty of rubbing people the wrong way, often causes the contractor a lot of unnecessary trouble. A contractor's reputation is based on the results he delivers and a reputation for doing good work in an efficient manner is a valuable asset for any contractor to have. A contractor's reputation is largely in the hands of the organization actually performing the work. It takes time to build up an organization of superintendents, foremen and engineers who are worth while.

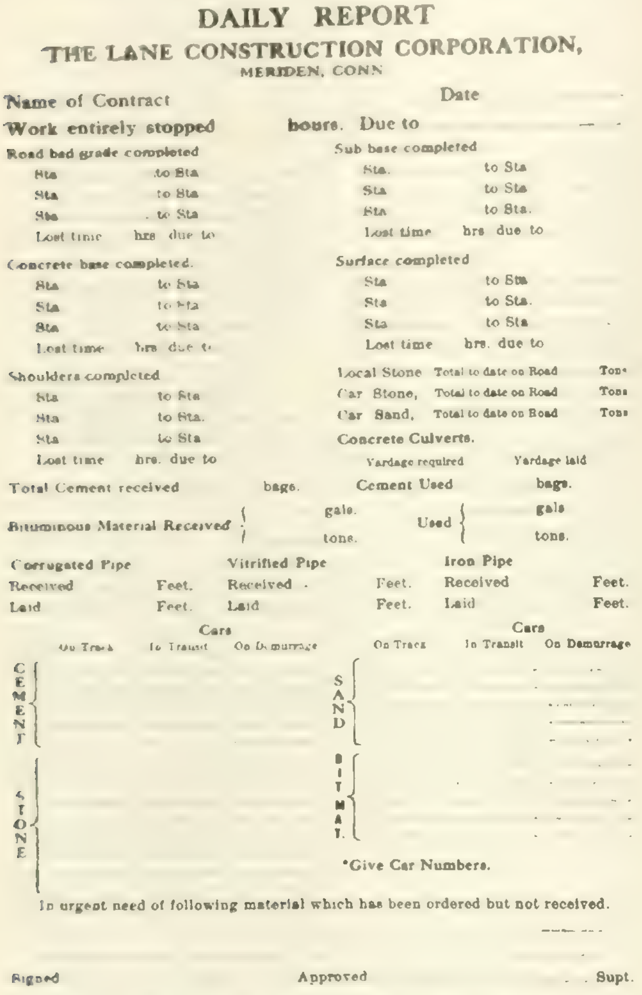
A contractor should observe closely the work of his men and the undesirables should be dropped. Those that are worth while should be given an incentive to stay. Some men in any organization are brighter than others. By selecting such men and giving them more responsibilty and observing how they perform their new duties may result in placing them in charge of work either as foremen or superintendents. Men brought up from the ranks in this manner usually have a sense of loyalty and appreciation that otherwise would be lacking.

Importance of Careful Planning and Co-ordination of Work.—Planning and co-ordination of work are of extreme importance in the successful accomplishment of highway construction. The type of work and the size of the job determines the kind of equipment that is necessary. The time in which the job must be completed and the availability of plant will influence its selection, and the amount of labor required will depend upon the methods adopted. If advantage can be taken of some particular method of the manipulation of material, the economy of such a method should be considered with relation to the new and special equipment that it might require. Buying special equipment that is not suitable for general use on work is usually inadvisable.

When the methods to be used have been determined, a progress plan of the work should be made. The need of plant and materials necessary for the work should be anticipated far enough in advance so that no delays will occur for lack of them. A well defined plan of progress will enable the contractor to keep the different parts of the work more closely co-ordinated than if no such plan is made.

A daily report of progress may be made on a form similar to the one shown in Fig. 1. The report should show each day the total of the work performed to date. By comparing these reports to the progress anticipated the work can be speeded up where necessary, or the original plan modified to suit the conditions which prevail. Another valuable feature of this report is the listing by car number of the material imported by rail. Material which is slow in arriving can be traced and rushed and one only has to look at the last report to learn the whole situation. Careful planning will prevent having too many laborers on work that cannot work to advantage because some other part of the work is held up for a cause that could have easily been prevented.

Many of the items of work [illegible] contract are difficult of exact measurement until the final survey is made. The daily expense on the job should be kept and classified into as many divisions as the contractor may desire. There should be at least as many sub-divisions as there are items in the contract and sometimes it is advisable to make further subdivision. To illustrate, the following table is given which shows on left side the contract quantities and on the right side the subdivisions that might be made in classifying the costs:



DAILY REPORT

THE LANE CONSTRUCTION CORPORATION,
MERIDEN, CONN

Name of Contract Date

Work entirely stopped hours. Due to

Road bed grade completed
Sta to Sta
Sta to Sta
Sta to Sta
Lost time hrs due to

Concrete base completed.
Sta to Sta
Sta to Sta
Sta to Sta
Lost time hrs due to

Shoulders completed
Sta to Sta
Sta to Sta.
Sta to Sta
Lost time hrs. due to

Sub base completed
Sta. to Sta
Sta to Sta
Sta to Sta.
Lost time hrs due to

Surface completed
Sta to Sta
Sta to Sta.
Sta to Sta
Lost time hrs. due to

Local Stone Total to date on Road Tons
Car Stone, Total to date on Road Tons
Car Sand, Total to date on Road Tons

Concrete Culverts.
Yardage required Yardage laid

Total Cement received bags. Cement Used bags.

Bituminous Material Received { gals. tons. Used { gals tons.

Corrugated Pipe		Vitrified Pipe		Iron Pipe	
Received	Feet.	Received	Feet.	Received	Feet.
Laid	Feet.	Laid	Feet.	Laid	Feet.

	Cars On Track	Cars In Transit	Cars On Demurrage		Cars On Track	Cars In Transit	Cars On Demurrage
CEMENT				SAND			
STONE				BITUMAT.			

*Give Car Numbers.

In urgent need of following material which has been ordered but not received.

Signed Approved Supt.

Fig. 1—Form for Daily Progress Report.

Contract headings	Headings for cost classification
28,500 sq. yd. grading	Grading
28,500 sq. yd. 2-inch Topeka	2-inch Topeka
	Plant Repair
	Asphalt
	Filler
	Sand
	Stone
	Mix
	Haul Mix
	Lay Mix
	Roll Mix
	Coal and Oil
1,375 cu. yd. sand fill	Sand Filler
[illegible] tons trap rock	Trap Rock
	Stone at Car
	Load
	Haul
	Spread
	Roll
	Coal and Oil

A superintendent can roughly estimate the daily output on the different parts of the work and from his classified expense arrive at the unit costs of the work. The frequency with which the daily classified costs should be sent to the office is optional with the contractor. While some prefer to know the total expended each day, others do not require the classification costs to be submitted except with the payroll, which may be once a week or once in two weeks. A superintendent should approximate his unit costs from day to day. The need for checking up the cost of work oftener than every one or two weeks is not so essential in the case of superintendents in whose ability the contractor has the utmost confidence, as it is in the case of superintendents whose knowledge of work is not so proficient. An analysis of costs will sometimes show where expensive mistakes are being made which can easily be avoided.

If a contractor has certain rules or methods which he wishes followed in conjunction with the work, it is advisable that he prepare a set of instructions covering them and put it in the hands of each superintendent. Much confusion will be avoided by doing this and there should be no excuse on the part of the superintendent for his failure to comply with the written instructions. Written work and reports of superintendents if made on printed report forms furnished by the office will facilitate the recording and filing work of the office in a marked degree.

Relation of Highway and Motor Transport Movement to Education*

By C. J. TILDEN,

Director Highway Transport Education Committee,
U. S. Bureau of Public Roads.

Topics which were of utmost importance a few years ago, and in which college courses have been established, may cease to have the relative importance in changed commercial and industrial conditions. A case in point is the theory and science of railroad location, a vitally important subject a generation or so ago. Today the problems of highway location, construction and maintenance are far greater than in railroad work, and yet most of the older colleges devote much more time to railroad courses than to those in highways.

Just what is the situation today as regards highways? And how are the highways, as more or less organized systems of transportation, being used by the citizens who build and support them? It may be well to review briefly some of these questions and then see in what way the colleges can help in fitting future citizens to take their part in this important development.

Distribution Now the Chief Problem.—It has been said that the chief problem before the country today is that of distribution. The fundamental problems of production have been largely solved. While there are many details that are still being worked out and certain new problems constantly arising in systematic production, the basis principles are pretty well understood. The same may be said of transportation. Railway organization has been thorough, operation systematized, and up to the time that the government took over operation during the war our railway system as a whole was pretty generally satisfactory. Water transportation is limited, but it has always formed an important part of the transportation system of the country, where it could be used economically.

Highways have always been a most vital part of our general transportation scheme, reaching as they do every community and each individual farm, and bringing them into contact with the main centers of distribution, whether railway or waterway. This universal need for roads has led to a basis of highway building entirely different from that of railway building. The highways are free paths over which anyone may travel; they are built and maintained by public funds (except in the very rare instance of toll-roads) and an important body of public laws has developed, regulating their construction and use.

The Highway Field and Its Opportunities for Engineers.—During the war our highways were enormously overloaded. Not only was railway transportation necessarily limited, but the greater convenience and speed in many instances of the motor truck brought that phase of transportation very much to the foreground. It was soon discovered, however that certain roads, built on what were supposedly the soundest principles of highway construction, would not stand up under the rapidly increasing loads of heavy trucks. Many miles of road were destroyed. It was evident that new principles of highway construction must be developed. Engineers are still seeking the best way of meeting this new problem, and many are at work on research along these lines. Foremost of these research agencies is the United States Bureau of Public Roads which has been and still is doing unusually fine work in the scientific investigation of highway materials, methods of construction, and other problems relating to the road.

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*From a paper presented Feb. 9 at the convention of the American Road Builders' Association.

Since the war there has been a remarkable increase in highway building, reconstruction and improvement. The generous appropriation of Federal money apportioned to the states under the Federal Aid Act has stimulated this activity to a large extent. In the current year 1921 there is available for highway construction and maintenance several times as much money as has ever been spent for that purpose in a single year before. While the figures are not as yet exact, a careful investigation by the statisticians of the Bureau of Public Roads within the last two or three weeks places this total at $697,000,000, an average of about $2,000,000 a day available for expenditures in building, maintaining and improving roads. This is of course for the country as a whole, and include state and county appropriations as well as those of the Federal government. It does not, however, include entire bond issues, but only such portions of these as are available for the current calendar year. The total stated above, therefore—nearly $700,000,000—is the amount actually on hand ready for spending in 1921. It will probably be physically impossible to spend it all within the 12 months under existing industrial conditions, but the fact that it has been voted, with such unanimity throughout the country, is striking evidence of the great importance which the people generally attach to our great highway program.

The work throughout the states will call for upwards of 10,000 engineers in all grades—a figure that is probably underestimated, rather than the reverse. This is an estimate made by Mr. MacDonald, chief of the Bureau of Public Roads, some months ago, and includes only those who have, or should have, education and experience along civil engineering lines. The supply is far short of the demand, which means, of course, that in many sections of the country inexperienced and untrained men will be put in charge of the expenditure of large amounts of money. The result will inevitably be a great economic waste. The universities and technical schools can not turn these men out in sufficient numbers of course, within a few weeks, and the falling off in enrollment during the war will limit the number of engineering graduates for 2 or 3 years to come.

With reference to the use of highways, the increase in the number of vehicles of all kinds is a matter of such common knowledge that it need not be stressed. Passenger vehicles have multiplied many times in a very few years. This is undoubtedly one of the most potent causes for the increased interest in highway building. The increase in motor transport, however, while the actual number of motor trucks is very much less, raises a far more serious problem. The natural development of economic principles has led to a great increase in the capacity of single truck units. Where the driver's wages form a substantial part of the cost of operation, a 1-ton capacity truck means a higher rate per ton-mile than a 5-ton capacity truck, but it has been demonstrated that the 5-ton truck (or heavier) requires a much more expensive road than the lighter vehicle, for many of the older roads were badly torn to pieces by the heavy trucks. It seems reasonable, therefore, that if we add to the cost per ton-mile for operating the truck the legitimate overhead charges—interest on first cost of road, maintenance, rebuilding, etc.—the heavier truck would not show so great an economy. With our present system of highway construction, where is the economist who can tackle this question and determine how the cost of improved highways may be equitably charged up to those who reap the chief benefit? Or else prove to the satisfaction of all taxpayers that a large initial expenditure is justified? Here is surely a research problem of the highest order.

Highway Transport—A New Activity.—The use of highways for motor trucking, a comparatively new activity well named "highway transport," is growing fast and "motor express" lines on a systematic basis will unquestionably be establishd in large numbers in the near future. Not only will this fill an important economic need, but it will furnish to young men of adventurous and roving tendencies opportunity for an active outdoor life with plenty of the spice of variety and even a touch of danger that is so appealing. For some time past the Goodyear Co. of Akron, O., has operated a line of trucks between Akron and New York City. In talking last summer with one of their chauffeurs, I was particularly impressed with the point just made. The trucks are large and fitted with pneumatic tires. They travel normally at a pretty good speed, from 25 to 35 miles an hour, and run continuously. Each truck is manned by a crew of two who work in six-hour shifts. A small bunk just back of the driver's seat permits the man off duty to get his rest, such as it is, while in case of an emergency both men must turn to and correct the trouble. The man I talked to was a wiry, snappy, clear-eyed youngster, for whom it was evident the work had a peculiar fascination.

A development of highway transport of unusual interest has recently been carried out by one of the large manufacturers of motor trucks. This consists of an economic survey of a county in Pennsylvania which had in it no transportation facilities whatever other than highways. It so happened that there were no railways, either steam or electric, in the county, although it comprised many square miles of productive land. With the assistance and hearty support of the principal bank, two of the truck manufacturer's engineers made a comprehensive study of the entire proposition of getting the products of this county to the nearest railroad center and bringing back the commodities that were needed by the inhabitants. A final estimate was made of the number and capacity of trucks that could be economically operated, a detailed statement of the routing, and an estimated balance sheet showing the probable return on the investment, as well as the great advantage to the community and possible stimulation to further productivity. The report was an admirable document in every way and was most suggestive as to possibilities along this line for many similar communities throughout the country.

1,000 C. E. Graduates Required Annually for Highway Work.—It is difficult to point out with any degree of certainty the educational need in connection with such a rapidly changing and quickly developing activity as that of the construction and use of highways. One point has already been touched upon, and that is the need of trained engineers to undertake highway construction as a public service. The idea of public service can not be overstressed. At the meeting in Washington last May, called by the Commissioner of Education for the purpose of considering current needs in highway education, it was estimated that for the next three years there would be about 1,100 civil engineering graduates turned out each year. Many of these will go into structural engineering, a number into sanitary work, or other branches of the profession, and a great many—indeed the majority of them, if we can trust the statistics of years past—will turn to business or other work not connected with professional engineering. On the basis of the 10,000 or more engineers needed, which is admittedly conservative, and on the further basis of an annual "turn-over" in this force of 10 per cent, we have at the very least 1,000 civil engineering graduates who could be absorbed annually by this highway work. This, be it remembered, is the work with highway construction, and does not include any other activities, such as the management and operation of highway transport lines. The enrollment is increasing in our technical schools in a gratifying way, but the boys who are entering now will not be available for three or four years. There is a tendency on the part of engineering students to shy away from highway work because the subordinate positions do not pay as well as those in some other lines; but the higher places, which can be reached only through experience, are well paid, and the present tendency of certain states and counties to offer substantial salaries to their chief engineers and principal assistants will in time attract the attention of students.

Preparing Men for Motor Transport Engineering.—With one or two noteworthy exceptions nothing has been done by the universities and technical schools to prepare men for the business of motor transport, such as is done for example, in railroad administration and operation. Perhaps this is inevitable. It may be that the need and the opportunity must be more apparent before there will be sufficient demand on the part of college students to justify the establishment of specific courses. There is another side to that, however, and that is the chance that the colleges have to take the initiative, show the wonderful opportunity there is in this field, and point out in carefully planned courses of study the rational basis and underlying business and engineering principles of motor transport activities. In other words, instead of letting the business grow up and then fitting men to take care of it, why not train men to establish, promote, and manage the business which is undoubtedly there simply waiting to be developed?

One of the exceptions noted above deserves special mention. A strong highway department has recently been established at the University of Michigan, under the able direction of Professor Arthur H. Blanchard, the well-known highway engineer. The department offers carefully planned courses in highway transport engineering as well as in the older fields of highway construction and maintenance. With well-equipped laboratories, and a large student body, and located in the center of a community which has always supported roads generously, the new department has a most promising future for rapid and useful development.

Combining Motor Truck and Industrial Railway Haulage on Concrete Road Job

By adopting a combination of motor truck and industrial railway haul, the contractor for a 5-mile reinforced concrete road job in Bradford County, Pennsylvania, so arranged the work as to secure the maximum use of the completed pavement. This meant that periods of wet weather, which would have made the unimproved road impassable for trucks hauling dry batches, did not prevent the transportation of materials from the loading station by truck to the end of the concrete open to traffic, and from that point to the mixer by industrial railway. The method is described in the March-April Concrete Highway Magazine.

The only railroad point available was at the northern end of the job. The mixer was started here and materials delivered by the industrial railway, which was placed along the shoulder. As soon as the first section of concrete had been cured sufficiently, 4-ton trucks, each carrying three steel, tipover, batch boxes, were put into service. Stone and sand for a 4-sack batch were carried in each box and sacked cement hauled out to the transfer point in a separate truck.

The batch-box transfer consists of an I-beam mounted at each end on a wooden tripod, with sufficient distance between supports to provide clearance for two trains and a truck. By means of a chain block suspended from a 4-wheel carriage, which runs on the lower flange of the I-beam, loaded boxes are picked up and placed on the cars, two to the car, except that one car of a train carries a single box. This makes it possible to transfer a loaded box to fill the empty space, and then to move empty and loaded boxes alternately.

Three trains of six cars each and two 3-ton gasoline locomotives make up the rolling stock. Five cars in each train carry a total of nine boxes, and the sixth car is for cement. One train is always loaded, another is being loaded, while the third is at the mixer or en route to or from the transfer point. At a signal given at the mixer, the loaded train leaves the transfer station and passes the returning empty train at a siding a few hundred feet from the mixer.

Arrangement for Transferring Batch Boxes from Trucks to Industrial Railway.

A derrick attached to the mixer frame dumps the boxes. Cement is added at the skip.

The contractor is the B. G. Coon Construction Co., of Luzerne, Pa., and J. S. Ritchey is district engineer for the Pennsylvania State Highway Department.

Meeting of Society for Promotion of Engineering Education.—The 29th annual meeting of the Society for the Promotion of Engineering Education will be held at Yale University, New Haven, Conn., June 28-July 1, 1921. Dean F. L. Bishop, [illegible] of Pittsburgh, Pa., is Secretary of the Society

Improved Model A Little Giant Road Crane

A new, improved Model A, Little Giant road crane embodying certain marked refinements has been brought out by the Locomotive Crane Co. of America, Champaign, Ill. One of these refinements consists of the substitution of steel castings throughout wherever parts are exposed to strain or actual wear. The improved Model A has been further refined by an innovation in design. It is now equipped with an independent, swinging engine; that is, a self-contained unit, consisting of a double cylinder, throttle, reversing engine has been provided. This engine is securely bolted to the rotating frame with the vertical swinging shaft bearings fitting snugly into and passing through the frame of the swinging engine itself. This, it is claimed, makes possible perfect alignment of the shaft at all times, and with the perfect balance of the engine, the rotating operation is accomplished without any jerking either on starting or stopping. The flexibility of the steam engine eliminates the necessity of friction slip rings. The weight of this machine is 29,000 lb., including a ¾ yd. clam shell bucket.

Model A Little Giant Road Crane.

Pump for Handling Paving Liquids

A steam jacketed pump for handling heavy road oils and paving asphalt liquids has been developed by the Viking Pump Co., Cedar Falls, Ia. The pump has but two moving rotors, which rotate in running clearance. These annular rotors are placed eccentrically inside of a round casing, making it possible to entirely surround the pump casing with a steam jacket, affording opportunity of effective heat application during passage through the pump proper.

The Viking principle is indicated by Fig. 1. The small rotor, mounted eccentrically on a stud-shaft in the cover plate, operates as an idler in balance, being driven by the large rotor which is integral with the driving shaft. The crescent shaped portion fills up the space between the rotors acting as a motionless valve to prevent the return of the liquid passing through. The teeth of the rotors are machined so as to permit of rolling contact and do not rub each other, nor do they scrape or rub the interior of the pump casing or cover plate. The dis-engagement of the small rotor teeth while in operation creates a strong suction effect, similar to that of piston strokes. This pulls the liquid into the pump filling the spaces between both rotor teeth. The crescent preventing the return, the liquid is carried on around until the meshing of the rotor teeth,

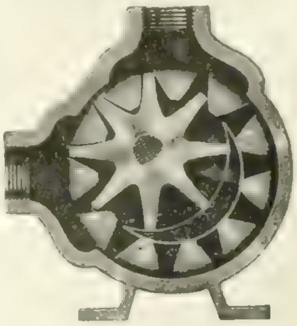


Fig. 1.

forming an impassable barrier between suction and discharge ports, forces the liquid out the discharge port. Remembering that the rotors are continuously rotating, it will be readily seen that the pumping action is positive and non-pulsating, avoiding the need of an expansion chamber. The liquid is drawn in and discharged with a steady, even flow and each revolution delivers a certain definite amount of liquid regardless of driving speed or pressure. The Viking pump, therefore, does not depend on scraping action of any kind and is totally free from valves. The Viking steam jacketed pumps can be furnished in two sizes, to answer practically every pumping need in connection with paving liquids. This includes installation on road-oiling motor trucks, as well as in pumping from tank cars to storage and other installations requiring pumps. They are offered with vertical steam engine drive, and with belt drive or electric motor drive in self-contained compact units. The Schirmer Co., 1006 Guardian Bldg., Cleveland, O., are general distributors,

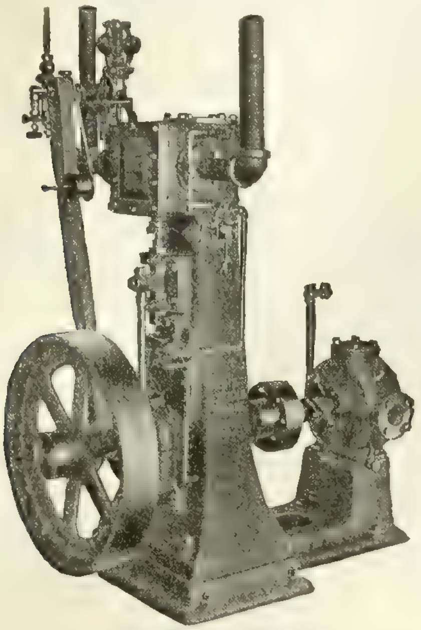
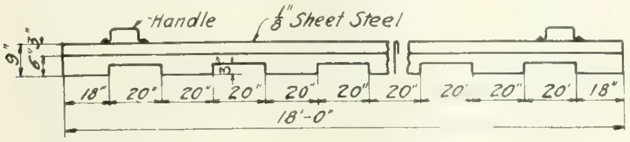


Fig. 2.—Viking Pump Direct Connected to Erie Engine.

Special Device for Holding Joint Filler

In the construction of the 9.4 miles of 18 ft. wide concrete road between Butte and Anaconda, Mont., elastite joints were spaced 30 ft. A specially designed device for holding the joint filler while the following section was being placed was used on this work.

This holder, which gave excellent satisfaction, was made of sheet steel, 1/8 in. thick and about 9 in. deep, with a 3-in. lip doubled back at the top. Slots were cut in the bottom of the holder so as to enable the concrete in the new slab to come in contact with the joint filler. At each end of the holder a handle was welded to the top of the lip. The joint filler was placed in the groove formed by the slotted steel and the lip, and the device staked in place with steel pins across the subgrade. After concrete has been placed on both sides of the joint, the holder is easily lifted out by the handles on each end, leaving the filler in correct position with minimum disturbance of the fresh concrete.

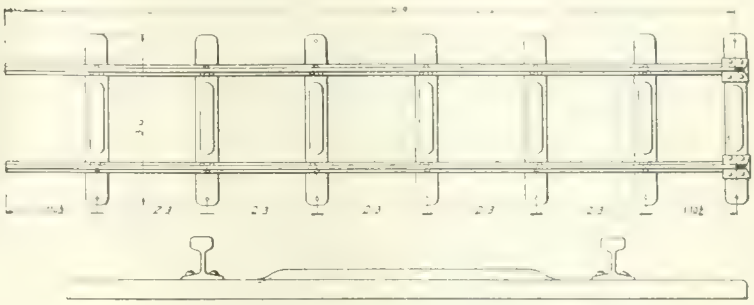


Device for Holding Joint Filler.

Bonus System for Road Construction Crew.—For the purpose of encouraging individual effort among the workers a bonus system of payment was employed for the crew engaged in constructing a 9.4 mile concrete road between Butte and Anaconda, Mont. The pavement was a 1:2:3 mix, 18 ft. wide, 6 in. thick at the edges and 8 in. thick at the center. At average efficiency the gang of 27 men was expected to put in a 30 ft. slab every 53 minutes, or 9 slabs per 8-hour day. For a full day's run a bonus was paid for each slab over 9. If work was stopped at the end of 5 hours and 18 minutes (two-thirds of a day) a bonus was paid for each slab over 6 completed, the purpose being to fix the bonus for each slab placed and not only for a big run during an entire day's operation. For each slab placed above the required amount the sum of $12 was paid, to be distributed equally among the 27 men employed. The average day's run was 12 slabs, allowing a bonus of $36 for the 3 slabs over the 9 required in an 8-hour day. The maximum run was 13½ slabs. Clifton, Appelgate & Toole, Anaconda, Mont., were the contractors.

Industrial Railway Track

A new design of Koppel railway track for use in road building is illustrated below. The principal difference between this type and the old one is in the tie. The new tie has a web in the center which is claimed to increase its strength by at least 35 per cent. For 24-in. gage track this web is 18 in. long and has an elevation of 5/8 in. Another improvement is in the construction of the end tie. The clasps on this come up much higher than in the old design. They cover the entire web and holes are provided so that the rails can be bolted together when necessary. The track is made by the Koppel Industrial Car & Equipment Co., Koppel, Pa.



Riveted Track with Koppel Pressed Steel Ties.

Concrete Road Construction on Adobe Sub Base

In preparing the adobe sub base for a concrete road in Stanislaus County, California, a procedure almost as exacting as that required in the construction of an earth dam was followed. This road was built in 1917 between Newman and Patterson and for a distance of several miles north of the latter place. The concrete pavement is 16 ft. wide and 4 in. thick, slightly reinforced at the expansion joints and corners. Sections of it are covered with 1 in. of Topeka asphaltic concrete. The surface of the road is maintained about 18 in. above the general ground level. The Department of Agriculture has classified the soil on which the road is built as "Yolo adobe" and "Yolo sandy clay."

Engineers of the Automobile Club of Southern California and the California State Automobile Association when making a study of the state highways of California inspected the road in 1920 and reported it to be in fine condition over all classes of soil except at its extreme north end, where it was laid through the small town of Westley, largely under the direction of the local authorities as distinct from the regular organization. The road was built under the direction of Lloyd Aldrich, at that time county engineer of Stanislaus County. The procedure as laid down by Mr. Aldrich in this work for the preparation of the sub base is outlined as follows in the recently issued report of the above mentioned clubs:

1st. Plow the entire space across the roadway between gutters for a width of 40 ft.

2nd. Make fill with scrapers in layers of not over 6 in.

3rd. As fills are made the material is pulverized with a spiked roller such as was used in former days with oiled roads. The fill is then sprinkled and built up in thin layers so as to moisten the adobe but not to work it into any liquid or soft condition. The moisture in this sub base is brought to a consistency such as is contained in the underlying deeper soils.

4th. A 10 to 12-ton 3-wheel roller follows the pulverizing and the entire 40 ft. of road-bed is thoroughly rolled in this manner to a uniform degree of hardness. As much attention is paid to the rolling of the shoulders [illegible] the central portion of the road.

5th. Header boards are all set in excavation. That is, a groove is dug in which the header [illegible] to a solid condition of rest. The sub base is then scarified to a depth of 3 in between the header boards. The loose material is then taken out from between the boards to within a depth of [illegible] in. of subgrade.

6th. The subgrade is then [illegible] and rolled again or not, as required.

7th. The surface is then cut to [illegible] with a special cutting machine. No cuts in excess of [illegible] in. are permitted. Any holes that are developed in this process are scarified, filled and rolled.

8th. The finished subgrade is then sprayed with water so it shows a sheet over its entire surface. This does not mean a standing pool of water, but rather a film of water. The sprinkling is repeated on the following day.

9th. The subgrade is then left for five or more days to dry. (Mr. Aldrich states that shrinkage cracks do not develop in the subgrade during this period.)

10th. The concrete is then cast on the subgrade.

Average Contract Prices California Highways, 1912 to Dec. 31, 1920

To indicate in some measure how the costs of the state highways of California have increased year by year, a study was made by the State Highway Commission of the two principal items of work which affect the cost, namely, the earthwork and the concrete. The following table from the second biennial report of the Commission covering the period ending Dec. 31, 1920, shows the weighted average contract prices on these items from 1912, at the beginning of the work, to Dec. 31, 1920:

Grading (all classifications), per cu. yd.	$0.62
Concrete (including all materials), per cu. yd.	8.08
Sand (delivered), per ton	.68
Broken stone and gravel (delivered), per ton	.90
Cement (delivered), per bbl.	1.88
*Concrete (exclusive of materials), per cu. yd.	3.81

*This is the item upon which the contractors bid in most cases; the state supplies the material.

Taking certain significant periods into consideration, namely, the pre-war years, the years of the war, and those since the armistice, brings out some interesting facts. The figures follow:

WEIGHTED AVERAGE CONTRACT PRICES, 1912-1916 (INCLUSIVE).

Year.	Grading[1] (per cu. yd.).	Concrete, including all materials (per cu. yd.).	Sand, delivered (per ton).	Broken stone and gravel, delivered (per ton).	Cement, delivered, (per bbl.).	Concrete,[2] exclusive of materials (per cu. yd.).
1912	[illegible]	$5.82	([3])	([3])	$1.61	([3])
1913	0.46	5.91	$0.56	$0.58	1.65	$2.56
1914	0.51	6.75	0.54	0.85	1.70	3.03
1915	0.47	6.26	0.58	0.76	1.74	2.84
1916	[illegible]	6.37	0.60	0.76	1.80	2.90
Weighted average	$0.49	$6.35	$0.56	$0.78	$1.70	$2.92

WEIGHTED AVERAGE CONTRACT PRICES, 1917 AND 1918.

Year.	Grading[1] (per cu. yd.).	Concrete, including all materials (per cu. yd.).	Sand, delivered (per ton).	Broken stone and gravel, delivered (per ton).	Cement, delivered, (per bbl.).	Concrete,[2] exclusive of mterials (per cu. yd.).
1917	[illegible]	[4]$8.03	$0.66	$0.86	$1.80	$4.17
1918	0.78	[4]10.51	1.05	1.28	2.20	5.53
Weighted average	$0.73	$8.67	$0.76	$0.96	$1.90	$4.51

WEIGHTED AVERAGE CONTRACT PRICES, 1919 AND 1920 (TO DECEMBER 31, 1920).

Year.	Grading[1] (per cu. yd.).	Concrete, including all materials (per cu. yd.).	Sand, delivered (per ton).	Broken stone and gravel, delivered (per ton).	Cement, delivered, (per bbl.).	Concrete,[2] exclusive of materials (per cu. yd.).
1919	[illegible]	[illegible]	$1.1[illegible]	$1.33	$2.64	$6.37
1920	1.10	16.92	1.23	1.41	2.68	7.64
Weighted average	$1.01	$15.43	$1.1[illegible]	$1.37	$2.66	$7.00

[1] [illegible] [2] [illegible] the contractors bid [illegible] most cases, the state supplies the materials. [3] In 1912 the contractors in all cases except one furnished the concrete aggregates. [4] In 1917 and 1918 the paving concrete was enriched from 1:2½:5 mixture to 1:2:4. In the prices stated allowance has been made for this change.

These data show that during the [illegible] the earthwork cost about 51 per cent and the concrete about 37 per cent more than during the pre-war period and that since the armistice the earthwork has cost 106 per cent and the concrete [illegible] per cent more than they averaged before the war.

It is also worth while to note that before the war the cost of the cement delivered averaged $1.70 per barrel and that since the armistice the cost has advanced to [illegible] per barrel or approximately 56 per cent; also, that the labor, hauling and manipulation cost of the concrete shows an advance during the same interval from $2.92 to $7 per cubic yard, or 240 per cent. It is estimated that the total advance in freight costs on all shipments of construction materials is at least 300 per cent above the pre-war charges.

Personals

B. A. Briggs has been appointed superintendent of streets of Colorado Springs, Colo.

Lafayette Higgins has resigned as sanitary engineer of the Iowa State Board of Health.

Graver & Dinkelberg, engineers and architects, have removed their offices to 500-501 Wrigley Bldg., 400 N. Michigan Blvd., Chicago.

Industrial Notes

D. Henry Bonner, whose resignation from the Ford Motor Co. was recently announced has joined the Four Wheel Drive Auto Co. in the capacity of sales manager. Mr. Bonner went with the Ford organization in 1914 and made rapid progress holding many responsible positions. At the time of his resignation he was in charge of assembly operations in all of the branches in the United States.

Sauerman Bros., 322 S. Dearborn St., Chicago, have arranged with Mr. S. D. LeClair of San Francisco, Calif., to take over the manufacturing and selling rights on the power drag scraper of which Mr. LeClair is patentee. This gives Sauerman Bros. four different types of scrapers, namely, the "Crescent," "Type C," "Excavator" and "LeClair." All four types of scrapers are similar in one respect, they are all bottomless and thus require no power or mechanism for dumping.

The Equipment Corporation of America announces through its president, Mr. H. M. Capron, the purchase of a 10 acre tract of land on the Indiana Harbor Belt at Maywood, Ill., where it will erect a large plant for the rebuilding of heavy contractors equipment. Their present Union Ave. plant in Chicago will be continued to rebuild hoisting engines, concrete mixers, pumps and similar small equipment. This will give the Equipment Corporation of America five plants, including manufacturing plant at Chicago Heights.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Road Making Machinery.—Stroud & Co., Omaha, Neb. 32 page catalog illustrating and describing elevating graders, wagons, road maintainers, road machines, road drags, dirt moving tools, etc.

Road Building Equipment.—Baker Manufacturing Co., Springfield, Ill. 48 page catalog devoted to the road tools and earth moving specialties. Includes description of various methods of moving dirt with Baker-Mancy self loading scrapers. Road levelers, road graders, snow plows, etc., also are illustrated and described.

Concrete Mixers.—T. L. Smith Co., Milwaukee, Wis. 48 page catalog for Smith Non-tilting Mixers. Contains illustrations and descriptions of general engineering designs of the mixers, together with descriptions of the various mixers, and their equipment; also detailed specification tables, dimension drawings and tables of information on quantities and proportions for various mixes.

Road Building Machinery.—J. D. Adams & Co., Indianapolis, Ind. 56 page catalog devoted to road building and maintenance machinery. Contains brief illustrated history of road graders, together with discussion of the principles and use of the Adams adjustable leaning wheel graders. Descriptions and illustrations of road maintainers, scrapers, drags and sundry tools also are included.

Road Building and Maintenance.—Hercules Powder Co., Wilmington, Del. 116 page book, setting forth the basic principles un[illegible] road building and maintenance and calling attention to [illegible] of the more important results of present day ex[illegible]. The book was written by Andrew P. Anderson, Highway Engineer, U. S. Bureau of Public Roads. It is divided into five parts: Part I—Planning the Road; Part II—Road Materials; Part [illegible] Construction; Part IV—Road Maintenance and Repair; Part V—The Use of Explosives. The book is well written, well illustrated and contains a large amount of useful information.

Waterworks and Hydraulics Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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The Movement for More Forest Lands

Recently there has been considerable agitation for the development of forests in middle western and other states. The motives back of this agitation are undoubtedly good, but most newspaper articles on the subject have failed to make it clear that the movement is wisely undertaken or that the economic principles involved are well understood by some of its advocates. Granting the necessity of providing timber for future generations, we have failed to see in the articles referred to, any reference to what classes of lands and what localities are desirable for the purpose, and what are not so.

The writers seem to have contented themselves with a rather indiscriminate urging of tree planting and forest starting, which because of its impractical tone is quite likely to react adversely upon desirable forest projects. It is to be hoped that practical foresters will take steps to counteract the growing impression that tree planting projects are primarily a hobby of impractical sentimentalists.

The timber needs of the future we can not foretell. With somewhat greater certainty we can say that our food supply must be greatly increased. To the latter end two means will be employed—more intensive cultivation and the extension of cultivated areas. Importation from other countries is not a means which can safely be relied upon. Since the food requirement may be expected, as it always has done, to maintain first place among the needs of man, it is fairly clear that of the lands now cultivated, only those thoroughly unsuited to agriculture are likely to be forested, and such lands are too small in extent to be of much importance one way or the other. Furthermore, forest lands are still being brought under cultivation.

Our lands which can be of little use except for the raising of timber are of very great extent, but obviously some are much better suited to the purpose than are others—whether by virtue of their composition, climate or location—and it is these better lands which should be first utilized in a comprehensive plan of forestation. Any other procedure would be wasteful. The selection of lands and the kind of trees for planting may, we believe, be safely left in the hands of our expert foresters. As yet no real beginning has been made in this work, and it is to secure its practical start and continuance that attention must be given.

It has sometimes been stated that with the necessary physical data at hand only a compound interest formula is needed to solve the problem of what is a justifiable present expenditure for the benefit of the future, but we cannot concede that the case is so simple.

Assuming, in the absence of actual data, that it costs 10 cts. to start a tree and care for it in its early years, and assuming that the tree matures in 200 years with a yield of 8,000 ft. B. M. (a fair amount of merchantable timber for a log 4 ft. at the butt and 100 ft. long), and neglecting all expense during intermediate years we have a moderately striking example to consider. At 4 per cent compound interest the 10 cents initial investment will have grown to $250, or $30 per 1,000 ft. B. M. of standing timber for comparison with a present price of $20 per 1,000 ft. B. M. for boards ready for shipment at some of our western mills. But this example is one of exceedingly rapid growth. At 4 per cent an initial 10 cent cost would grow to $32,000,000 for a tree maturing in 500 years. What of a redwood that matures in 2,000 years? We can not, therefore, figure such expenditures as business investments for posterity; but we can, and should, consider them as gifts to posterity because we wish our country to be great and our descendents to be happy as far into the future as we can imagine the influence of our acts. How much we should give for such reasons no man can say, but assuredly we must give something unless we are willing to say with the courtiers of King Louis—"After us the deluge."

Instead of coming after, the deluge engulfed the gay courtiers of Louis; and while we cannot draw an exact parallel, we may well consider that a lumberless land may result sooner than is expected. The editor sometimes recalls with amusement a quotation which he once read from a report made to the government by an army officer in the very early days of development of the Puget Sound country. In sub-

[illegible] the roads were there. "Travel [illegible] and other ports on Puget Sound will always [illegible] because the land is covered by an impenetrable forest which will never be cut through." When Olympia got its first highway connections with other points we do not know, but its rail connections are of more than 30 years' standing. How little vision most of us have! The army officer may have lived to ride into Olympia in a Pullman car.

But provision of a future timber supply is not the most important reason for reforestation in many parts of our country. The preservation of the very land itself demands that it have trees. In China great areas of once fertile land have been ruined by the denuding of watersheds above them—the ground being progressively cut to pieces by unrestrained torrents following heavy rains; while through lack of absorptive power it becomes too dry for agriculture after the rains stop. For the same reasons certain Mediterranean islands have been changed from rich, cultivated territories to uninhabited deserts, and many other localities afford similar examples.

Of the extensive criticism of wasteful American methods of lumbering only a part has been deserved. In the development of new territory primitive methods must be used, and primitive methods are wasteful. In this country the one alternative to wastefulness was to leave the land undeveloped. The timber of the Pacific Northwest, for example, could not have been marketed had it been necessary to harvest it by the more conservative methods of the East. Had the Northwestern timber not been marketed the East would have paid a higher price for its lumber, forests of the Middle West and South would have been cut off much more quickly and completely, and the cities of Puget Sound would still be frontier settlements.

We have already given our endorsement of timber conservation, and that, if it means anything, means that we think needless waste exists and can be curtailed. It does not mean that we think it were better to preserve vast wildernesses until they can be so logged as to save every possible foot of timbr.

Protection from fire, reasonable care in logging methods, and reforestation are the means which must be looked to to conserve our diminishing timber supply for the benefit of ourselves and our descendents.

Wanted—A Scientific Rating of Profits

In spite of advances in the science of accounting, and to a lesser extent in the broader science of economics, our present methods of rating profit are unwarrantably crude. We think that we are not stating the case too strongly when we say that at present there is no established means of comparing the profits of a doctor, a merchant, a manufacturer, and a public utility. Yet a youth wishing to enter the most remunerative line of activity might fairly ask for such a comparison, and a body establishing income taxes or a body regulating rates cannot do full justice without an approximately accurate comparison of different classes of business.

By established custom the merchant figures his profit on each article as a percentage of its selling price—less commonly and less conservatively, as a percentage of cost. Among his costs he may or may not include interest on his plant and working capital, and all his direct and indirect expense of wages, salaries, etc.

The manufacturer's basis of profit is not well standardized, and many experts are busy devising means to show manufacturers what their true profits are, which lines are profitable and which unprofitable. Sometimes he computes his profit as a percentage return on investment, sometimes in terms of a year's business, and sometimes otherwise.

The doctor rarely rates his profit in any fashion. Expenses paid, deducted from total dollars earned, leaves a balance which he calls profit.

The public utility's case is simple. The law says that it may earn a fair percentage of the value of its property, and the utility manager knows that in most cases more than 8% will be held by the court to be excessive, while if earnings fall below 6% the court will permit him to increase rates.

What comparison exists between the utility's 8% on property value and the merchant's 15% or 20% on business transacted? None that we can see. Yet similar elements in varying [illegible] business, and they are not so numerous that a profit formula based upon them should be impossible.

First there is invested capital. The doctor's is comprised in the cost of his education and his equipment—a very important item to the individual, and unless his practice is highly remunerative, a fairly large one in comparison with annual income. The merchant's "fixed capital" in lands, buildings and permanent equipment is not usually large in proportion to annual business, and must be carefully distinguished from the "working capital" which he keeps invested in goods for sale. The manufacturer's fixed capital may be anything: often it is enormous. The utility's investment is usually conspicuous for its size in proportion to its annual business, but exceptions appear in such cases as express companies.

The second element is the cost of goods purchased and disposed of in the course of a business period—say a year For the doctor it is small; for the merchant it is the most important single item; for the manufacturer it may be either large or small (a few raw materials such as clay for brick making are still cheap in some places); for a water power utility it will be very small; for a gas plant, large.

As the third element there is the cost of labor—small for the doctor and large for the others in most cases, though comparatively small for hydroelectric utilities and for some others.

In the fourth place there are the items of taxes, rentals, advertising, etc.

Certainly this is not so large a group of elements as to discourage efforts at the solution of the problem. Even if there are omissions or if some subdivision should prove desirable, the array is not appalling.

We remember reading of a manufacturer who successfully produced an article in which the material was the chief item of expense; but when he attempted to turn out a product on which labor was the largest cost he nearly failed because he figured his profit on the same basis which he had used for the first article—the basis of the combined cost of labor and material. An efficiency expert showed him the simple but vital error of assuming that the same rate of profit is suitable on both labor and material.

Surely it is worth some one's while to develop a proper method for the comparison of profits. Should it prove more difficult than is expected to find the mathematically correct formula applicable to every case, the use of arbitrary scales is still possible. Many of our physical scales are not the less useful because they are arbitrary; and the introduction of an arbitrary scale has often resulted in the finding of some form of natural scale.

Race Segregation and City Planning

We assume that it is unnecessary to recite the nature of race problems or the evils which follow a mixing of white families and colored in a single residental district. Every large city of the North having a considerable negro population is confronted with one or more phases of the problem, and attempts at solution have been conspicuous by their absence or their weakness.

In Chicago, where depreciation of large amounts of very high-class residence property has resulted from negro intrusion, a plan is now in preparation by large financial interests whereby it is expected that the negroes will segregate themselves.

That the backers of this project are presumably actuated by hope of financial gain in some form, increases rather than diminishes its value, for such a motive is the one most likely to carry the plan to success with benefit to both negroes and whites. It is stated that under this scheme the colored population will be housed in a space one-third as large as that now occupied. It is not expected that every negro will at once move to the district chosen, but if the great majority settle there the problem as a whole will have been solved.

We believe that the promoters are correct in thinking that if given a favorable opportunity the colored people will settle the matter rightly. We know, of course, that there is the aggressive and offensive negro who, having enjoyed some form of success, wishes to thrust himself into the company of whites, but we believe that the very great majority will be content to live comfortably by themselves, and that there are many colored people who realize that the races are better separated and that their own self respect can be best preserved when they live separately.

The project of the Chicago realty men and financiers may not generally and at once be recognized as an accomplishment in city planning; yet if it is carried out, it will be that very thing and by no means a small accomplishment. In the Michigan Ave. extension, in the widening of certain streets and in other ways, Chicago has made a most creditable start toward a plan which will work to her ultimate great good, but she has dallied with the first and most important step toward securing an orderly city—a comprehensive zoning system. So long as any piece of property may be put to any use which the exigencies of the moment make profitable to the property owner we shall have disorder and incongruity. Natural development is to be desired but natural development does not result from a mere letting alone. A misuse of property is an abnormality on the city's body which may be well likened to a wart or a tumor on the human body—a blemish on beauty or a disease working desperate injury.

Of the latter class is a mixed racial district. We do not know what may be legally possible in forcing segregation; but segregation without resort to legal means is vastly to be preferred, and if it can be accomplished, great credit will be due to the business men through whose foresight and activity it is brought to pass.

In Our Industrial Controversies Give Us Facts, Not Assertions

Every citizen who prefers realities to pictures must deplore the prevalence of unsubstantiated assertion in the public discussion of our vital social and industrial problems. Such presentation stimulates resentment and hatred on both sides without contributing to or tending toward any solution except the solution of might.

Yet they constitute a very large part of the discussions by the champions of each cause. We do not ask the champions to halt the contest. A relaxation of effort by either side at the present time would probably result in still worse ills. But here is a quarrel in which a very large non-combatant public has so deep an interest that it may yet arise and deliver the decisive blow. In fact the frantic efforts of both sides to gain public favor indicate that this contingency is far from being overlooked.

Had either side been ingenuous we might say, "Woe unto the deceiver when the public shall learn that it has been trifled with"; but since the public is fairly well aware that both sides have often been tarred with the stick of misrepresentation, it is not likely to act because of outraged confidence.

Two motives should prompt the contestants to make all their statements as reliable as possible—a sense of common decency and the recollection that falsehood, however clever, usually suffers in the end. A Sunday school platitude? Perhaps, but still the truth. The desire for a righteous peace should prompt non-contestants to expose falsehood and error, and to publish the truth whenever possible.

We started with a reference to unsubstantiated assertion and passed to a consideration of falsehood. The two have much in common. They will be treated alike by the opposition. The impartial observer, having found a falsehood, will suspect every assertion. A mistaken assertion is in all respects as bad as a lie except in its effect upon its maker.

An example of assertion which is harmful through its bareness occurs in some of the accounts of the testimony of Mr. W. Jett Lauck, economist for the railway labor organizations in the recent hearings before the Railway Labor Board. Mr. Lauck's sensational statements are quoted by papers of varying political persuasions, but we have so far seen no single piece of supporting evidence. We do not ask for all the evidence or even for a large part of it, but we hold that the statements as published contain nothing by which they can be judged, and therefore that they constitute appeals to prejudice rather than to reason. Mr. Lauck's friends will accept his statements as coming from an honest and competent authority. His enemies will claim that every unproved assertion is a falsehood and will endeavor to discredit his data. The dispassionate observer will in so far as possible judge the statements on the basis of his own knowledge, but beyond that, will suspend judgment until he has the evidence.

What the average reader wants is a brief and convincing statement—a truly difficult thing to produce. It seems to us that the requirement can be most nearly fulfilled when, in addition to the principal assertions or contentions, there is published a resume of the most convincing evidence on some one of the claims—or if space is available, on more than one. Such a procedure would afford at least some opportunity to convince readers on the one point; and if convinced of the truth of one contention they are the more likely to accept others from the same source. The method is far from perfect but it is the most practical of which we have been able to think.

The New Republic almost makes a start in this direction when it prints the following in regard to Mr. Lauck's testimony:

"The total waste by the railroads he places at a billion dollars a year, and he divides this staggering total among a damagingly specific list of items. The application of well-known improvements to locomotives, for instance, would save $272,000,000 a year; better operation of locomotives would save $50,000,000 more; enormous sums could be retrieved from the waste column by improvements in shop organization, in cost accounting, in buying supplies, in obsolete power plants, in preventable loss and damages. Mr. Lauck quotes an official of the Southern Pacific to the effect that 'five times a minute, 300 times an hour . . . 2,529,000 times a year, an employe is lost and replaced.' In other words, he says, the labor turnover of the railroads is 140 per cent."

Regarding the "damagingly specific list of items" it would be interesting to be told what locomotive improvements would save $272,000,000 annually. Unquestionably improvements are possible, but $272,000,000 is too large a sum to be passed with a bare statement. Better operation of locomotives is also an unquestioned possibility, but what are some of the improvements which are to save $50,000,000 each year? If the labor turnover is 140 per cent is the management wholly to blame? And we should very much like to know if the hundreds of millions of savings which Mr. Lauck specifies are based upon a 100 per cent efficiency. It may be answered that no practical man would imply the possbility of a 100 per cent efficiency; but is Mr. Lauck practical, and is his partisanship so lofty that he scrupulously refrains from implications which he could not maintain if closely pressed? In the absence of further evdence the reader may well be in a quandary as to a decision.

We have read denials of the Lauck charges, and in general they were of no higher order than the charges themselves. If broad public sympathy is to be gained by either side it must be by more careful methods than those now commonly pursued.

State Development of Water Power Unnecessary

If private utility companies under public regulation were not exercising their stewardship to good account in the development and popularization of needed hydro-electric facilities, there would be some logic in looking to the state to supply the service. Given fair conditions, however, there is little reason to fear that private capital will be found wanting in this field, and long study of the relative merits of public conduct and private conduct of business affairs has led relatively few well-informed engineers and technical executives to champion the former. The attempt sometimes made by politicians to arouse interest in the state development of water powers on the ground that these are being held back from the people by private companies ignores the fact that in many cases a marketable surplus of hydro-electric energy may exist in the very territories on whose soil and over whose streams public ownership propaganda is being spread. In common fairness to the companies that are doing their efficient best to bring their service at reasonable rates alike to the home of the humblest citizen and to the largest industrial plant, let this unworthy imputation be confuted by hard facts in every case where it is utilized as an excuse for socialistic pleas for public power development!—Editorial in the Electrical World.

Cleveland Convention of American Waterworks Association

The tentative program for the 41st annual convention of the American Waterworks Association, which will be held at Cleveland, O., June 6-10, has been announced. The Hollenden Hotel has been selected as the headquarters, where the meetings will be held and the exhibits made. On the opening day, June 6, there will be a feature of special interest to waterworks superintendent. This will consist of group meetings of those interested in certain subjects or topics. These are intended to be get-together, get acquainted meetings, to talk over informally such topics or problems as each is specially interested in. Commencing Thursday forenoon, June 9, the convention will be under the control and for the benefit of superintendents, waterworks managers and operators. The tentative program of the convention follows:

MONDAY, JUNE 6.

Secretary's Convention Office open for registration at 8 a. m.

Executive Committee meeting, 2 p. m. Other committee meetings.

Group Meetings. Arrangements will be made to have members in attendance Monday meet in small groups interested in topics that will be announced later. This is a new feature and is intended to promote acquaintance and a get-together, helpful spirit.

Evening.

Address of welcome and informal reception with dancing.

TUESDAY, JUNE 7.

Forenoon:

President's address.

Papers:

Progress in Filtration, by J. W. Ellms.

Construction Progress of the Cleveland Water Works, by A. V. Ruggles.

Operation of the Mechanical Department of the Cleveland Water Works, by L. A. Quayle.

Afternoon:

Effect of Cleaning Mains at Kansas City on Their Capacity, by C. S. Foreman.

The Waste of Water in Detroit, by G. H. Fenkell.

Water Rates, by N. S. Hill, Jr., and J. N. Chester.

Election, by Districts, of members of the Nominating Committee.

Ladies' auto trip to the Cleveland Yacht Club.

Evening:

Water Supply From the Supply Man's Viewpoint, by Charles Ade.

Electrical Control of Valves, by Peter Payne Deane.

Experience in the Development of Oil Engines, by F. B. Leopold.

Standardization of Meters, by R. K. Blanchard.

WEDNESDAY, JUNE 8.

Forenoon:

The Romance of Water Storage, by Col. George A. Johnson.

The Water Works of Erie, Pa., by John N. Chester.

Reports of Standing Committees.

Reports of Special Committees.

General business.

Selection of place for holding the 1922 Convention.

Afternoon:

Licensing Operators of Water Purification Plants in New Jersey, by Charles H. Capen, Jr.

Improving the Scientific Features of Water Works Operation in Texas, by L. O. Bernhagen.

The Small Plant Operator as a Scientist, by Abel Wolman.

The Loading of Filter Plants, by H. W. Streeter.

Tastes and Odors With Chlorination, by W. A. Sperry.

Quality of Water at Different Points on a Water System, by S. T. Powell.

State vs. Local Viewpoint on Filter Plant Control, by Robert B. Morse.

Evening:

Theatre party for the ladies.

Smoker for the men, Rainbow Room, Hotel Winton.

THURSDAY, JUNE 9.

The Chemical and Bacteriological Section will hold separate meetings Thursday, program for which will be announced later.

Forenoon:

Report of Committee on Standardization of Water Meter Specifications, Caleb M. Saville, Chairman.

Use of Dynamite in Breaking Out Old Water Mains, by Alvin Bugbee.

Tapping Large Steel Mains Under Pressure, by D. F. O'Brien.

Afternoon:

Mechanical Aids in Distribution Work, by W. M. Mitchell.

Ownership and Operation of Trench Excavators and Other Mechanical Equipment by the Water Department of Baltimore, by V. Bernard Siems.

Other Practical Operation Papers.

Discussion of Superintendents' Topics.

Questions and Answers.

An afternoon card party for the ladies.

Evening:

Moonlight boat ride, with dancing.

FRIDAY, JUNE 10.

Forenoon:

Superintendents' Topics and Questions continued.

Superintendents' Day Program will be continued in the afternoon if there is sufficient material and interest.

Arrangements may be made for talks, illustrated by lantern slides and moving pictures for the evening.

The Dose of Alum for Classification of Water By Precipitation

Public Health Engineering Abstracts of April 23, contains the following note on this subject, the matter being taken from an article by Capt. J. Morison in the Indian Journal of Medical Research for April, 1916:

A large number of experiments on the action of alum on the turbid water treated by the Poona, Bombay, India, waterworks plant and on other waters showed that the best dose of alum for the perfect clarification of soft water is obtained by adding half the equivalent weight of alum necessary to react completely with the alkalinity calculated as calcium carbonate. For a hard water the same rule holds good; but an equally good clarification can be obtained by the use of a smaller dose and a mechanical filter. A watery solution of haematoxylin (logwood) gives a reddish color when the correct dose has been used. With doses in excess or in defect of this, a decoloration or a gradation of shades of purple or lavender is obtained. This can be used for a colorimetric estimation of, and hence a check on, the dose of alum actually used. The clarification obtained by adding the optimum dose of alum is not affected by the turbidity of the water within the wide limits of turbidity found in the Poona water.

It was found that with the use of smaller doses of alum, the nearer the approach to the optimum dose, the greater is the reduction of the bacteria per unit of alum used.

The experiments seemed to show that precipitated aluminum hydrate is a reversible colloid and not an irreversible colloid as usually described.

The rule, which decides the amount of alum that should be used to clarify water, helps also in deciding when alum alone will suffice for the treatment of a water and when a mechanical filter is a necessary adjunct. In the case of hard water, the optimum point for precipitation by alum is so high that the use of alum alone is prohibitive from the point of cost. Besides which, half the temporary hardness will be converted into permanent hardness. In such case, a much smaller dose of alum will be sufficient to form a film of aluminum hydrate on a mechanical filter the running cost of which may be cheaper than the difference in the cost of the alum.

On the other hand, with soft water, the dose of alum to obtain perfect settlement is low and exceeds by very little the dose necessary to enable a mechanical filter to act. The question then lies between the cost of alum for the optimum dose and the cost of running a mechanical filter plus the interest on its capital cost.

A point that still remains to be investigated is the optimum dose for a mechanical filter. At present no definite rule is observed for attaining this dose. It is highly probable that the most economical and yet efficient dose will bear some ratio to the optimum dose, and will vary with the alkalinity. At present the dose for a mechanical filter is entirely empirical, and it is likely that a considerable economy on the working of such filters, especially with a water varying in its constitution, may be attained by putting the method for finding the dose on a more scientific basis. It is probable also that the method described may assist in the economical precipitation of sewage and in the removal of silt from rivers; but in neither of these fields has the writer been able to test the method.

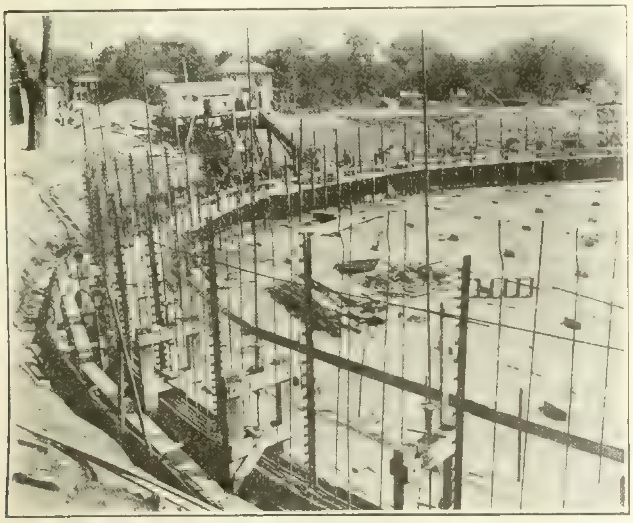
Production of Electric Power in U. S. in 1919—The total production of electric power by public-utility companies in 1919 was 39 billion kilowatt-hours, according to the United States Geological Survey. Of this power 62 per cent was produced by fuels—35 million tons of coal, 11 million barrels of oil, and 21.7 billion cubic feet of gas—the remainder by water power.

Construction Features of New Reinforced Concrete Covered Reservoir for Arkansas City, Kansas

By R. E. McDONNELL,
Of Burns & McDonnell Engineering Co., Consulting Engineers, Kansas City, Mo.

A 2,000,000 gal. concrete reservoir recently completed at Arkansas City, Kan., embodies some interesting features of design and methods of construction.

The water supply is obtained from wells equipped with motor-driven deep well type vertical centrifugal pumps located approximately 1¼ miles from the high service pumping station, and is pumped through a 20-in. wood stave pipe line to the reservoir located near the main pumping station. The reservoir provides a reserve storage for interruptions of power service, emergency demands and allows the well pumps to operate at uniform steady rates.



Concreting Operations for Arkansas City Reservoir.

The site available for the reservoir location was a low tract of ground that had been of a swampy nature and had been partially filled in with old refuse, brick, tin cans, street sweepings and rubbish. Test borings were made and the results indicated approximately an average of 8 ft. of old fill and original loam and 2 ft. of water-bearing sand overlying a solid limestone stratum, requiring 6 ft. of tight sheeting to hold lower banks. The ground water level was approximately 4 ft. above the rock surface. The rock surface was fairly smooth and level, having a grade or dip of less than 0.8 of 1 per cent. Several faults or cracks, from ¼ in. to 1 in. wide, averaging about 20 ft. apart, running straight angles to each other, were cleaned and grouted full with a 1:2 cement mortar and after chipping off some of the uneven places, the entire rock surface was washed with a cement grouting and used as a floor.

The reservoir is a circular reinforced concrete ring tension type, 156 ft. inside diameter and designed for a depth of 14 ft. of water. It is covered with a 5-in. reinforced concrete roof slab carried by 10 in. by 15 in. beams spaced 12 ft. centers each way and supported by 10 in. by 10 in. concrete columns. The roof was divided by expansion joints into slabs 24 ft. square and rests freely upon the beams. The slab was designed for 90 lb. live load in excess of the dead load. The entire roof was given a slope of 8 in. from the center to the outside walls.

A trench was excavated in the rock to provide a sub-footing under the walls and to secure a good bond to prevent leakage. In order to provide for the indeterminate cantilever stresses, the sub-footing was finished off smooth and an asphalt expansion joint was provided between the sub-footing and the wall footing proper.

The wall was made 14 in. thick without taper toward top, in order to facilitate the use of slipforms. The horizontal steel was placed in two rows and held in place by vertical standards, 6 ft. centers, built up of 3-in. channels, to which short strap steel lugs with notches for holding the bars were riveted at the required intervals. The channel standards facilitated the placing of the steel and insured the proper spacing and against the displacing during the pouring of the concrete. The standards were accurately centered and held in place by braces until the footing was poured and then the standards were sufficiently rigid to be self-supporting.

A system of slip forms 4 ft. in height and sections 12 ft. long were made up of 1 in. shiplap and assembled and centered in place. The forms were filled within 6 in. of the top and at this point they were raised by means of the ordinary slip form jack operating on a 1-in. jack rod. The jack rods were spaced approximately 8 ft. centers and two men made the circuit twice an hour raising the form about 1 in. each time. The 1-in. jack rods were cut off at the top of the wall when the pouring of concrete was completed.

The wall concrete was run continuously, requiring a total time of 80 hours for completion. Three 8-hour shifts, each consisting of 10 laborers and foreman mixing and placing concrete, three men placing and wiring steel, two men operating form jacks and two carpenters shifting runways and miscellaneous work. Two mixers were placed on opposite sides but owing to shortage of labor only one mixer was in operation at one time, the crew changing from one mixer to the other every hour. Concrete was conveyed from mixers to wall in wheelbarrows on board runs.

This method of construction eliminated all construction joints and gave a smooth finished surface which under water test showed practically no leakage and only slight leakage was found through the small fissures in the rock bottom. Column footings were placed and tops carefully graded from center to walls to conform to roof slope, so that all column forms were of same length, simplifying the construction and placing of forms. A part of the roof was poured during freezing temperatures, the work being protected by using a canvas tent covering, heated with steam coils, heating sand and water for mixing and covering completed work with paper and straw before removing tent to next section.

The location of the reservoir being on public park property, the top slab was given a float and trowel finish, the manhole openings and ventilators so placed that two tennis courts were laid out on top of the reservoir. Pipe couplings or sockets were installed in the roof slab for installing net posts and also round the wall for fencing the entire area.

Reinforced Concrete Reservoir of Arkansas City.

The principal quantities in the construction were 7,162 cu. yd. earth excavation; 1,038 cu. yd. concrete; 71.7 tons reinforcing steel and 4.2 tons channels and miscellaneous.

The total cost of the completed reservoir was $52,887. The reservoir was designed by Burns & McDonnell Engineering Co. of Kansas City, Mo., was constructed by Ray & Son, contractors, of Baxter Springs, Kan., and the work was inspected and supervised by Charles W. Lusk, city engineer of Arkansas City, Kan.

Operating Results of Experimental Activated Sludge Plant at Worcester, Mass.

The results of 12 months' operation of an experimental activated sludge plant at Worcester, Mass., showed that, for conditions as found there, it required about 4 cu. ft. of free air per gallon of sewage, 6 hours' aeration and 6 hours' re-aeration of the sludge, using about 25 per cent returned sludge and treating average to strong sewage, to produce a final effluent of good chemical quality and having a stability of from 75 to 90 per cent.

Without further experimentation, the city is proceeding to construct a treatment plant using Imhoff tanks and trickling filters. Previous experiments with the latter method proved it to be satisfactory for Worcester sewage.

A description of the experimental activated sludge plant with the results of operation were given by Roy S. Lanphear, Supervising Chemist, Worcester Sewer Department, before the Sanitary Section of the Boston Society of Civil Engineers. From his paper the data following were obtained.

The Worcester Experimental Activated Sludge Plant.—The experimental activated sludge plant consisted of a bar screen, grit chamber, sewage aeration tank, sludge re-aeration tank, sedimentation tank, sludge concentration tank and a shallow tank used for sludge concentration experiments and for measuring excess sludge previous to disposal.

Sewage was taken from the outlet of the main grit chambers in a 6-in. pipe line to the screen chamber, where it passed through the screen with ½-in. openings between the bars. It then passed in a trough, by a swivel gate, where excess quantities of sewage were wasted, to a grit chamber, 72x10x8 in. deep, formed by a depressed section of the trough bottom. The sewage flow was measured by a weir and hook-gage and then continued in the trough to the sewage aeration tank, the returned sludge entering this trough close to the tank.

The sewage aeration tank was constructed of wood and had a concrete bottom; it was 26 ft. long, 14 ft. wide and 10 ft. deep—water depth—and had a capacity of 25,283 gal. The tank was divided into three channels, giving the sewage a travel of nearly 80 ft. The bottom of the tank was of saw-tooth construction, rows of four filtros plates, Grade "S," being placed 45 in., center to center, giving a ratio of tank surface to working plate area of 5.2 to 1. Concrete blocks were placed between the rows of plates and had slopes of 1.5 on 1. Compressed air was delivered by a 4-in. header to three 2½-in. pipes, one for each channel. Each set of filtros plates was supplied with air by a 1-in. pipe which entered a chamber under the plates made by using a form when putting in the concrete bottom.

No baffles were used in either aeration tank, but such installation in the sewage aeration tank had been considered.

The effluent from the sewage aeration tank passed in a trough to a point above the center of the sedimentation tank and was measured by a wier and hook-gage. The inlet to the sedimentation tank was a box of increasing area of cross-section which extended down into the tank about 8 ft. This tank was of the Dortmund type, 14 ft. in diameter and 9.6 ft. deep, circular section, with a conical bottom, 9 ft. deep, having a slope of 1.5 on 1.0. The capacity of the upper section was 11,058 gal., and of the conical bottom, 4,017 gal. During operation, the conical bottom was usually kept filled with sludge to aid in returning sludge to the sewage which had sufficient and uniform density. The sludge did not slide down this slope readily, and a squeegee was used daily. The effluent was collected in a circumferential trough and the sludge settling to the bottom of the tank was raised by air lift and delivered in a trough, containing swivel gates, to the sewage or sludge aeration tanks or to either of the sludge tanks.

The sludge, with or without re-aeration, was returned to the sewage in a trough previously mentioned, and was measured as the difference of the combined sewage and sludge and the sewage flows. The sludge re-aeration tank was 12 ft. long, 5 ft. 4 in. wide and 10 ft. deep, and had a capacity of 4,386 gal. Its construction was similar to that of the sewage aeration tank and the ratio of tank surface to air diffuser area was 4.76 to 1.0.

The equipment for furnishing compressed air included two 10-HP. single-phase motors, belt-connected to two No. 2 Nash hydroturbine compressors or blowers. The air passed through cheesecloth screens and was washed with water in the compressors. Air used for aeration of sewage and of sludge was measured by Venturi meters connected to graduated manometer tubes, and that for the air lift, by a Westinghouse No. 12 gas meter. A pressure gage, thermometer, and a waste valve were suitably installed in connection with a storage tank placed between the compressors and the separate air supply mains. The quantity of air used was regulated by adjusting the valves on each supply main and the waste valve. On this account, together with interruptions of operation and the operation of one or both compressors, the pressure data are inconsistent. The average pressure increased from 5¼ lb. to about 6½ to 6¾ lb. in the winter, and during the second summer dropped to from 5½ to 6 lb., indicating the probability of slight clogging of the filtros plates. The higher pressure of winter may be explained in part by interruptions of operation and by the probable increased friction in the air distribution system due to condensation. The air distribution pipes were protected from the winter temperatures by covering with felt and boxing them in.

Operation of Plant.—From 125,000 to 165,000 gal. of sewage were screened daily, the screen raked once an hour, and an average quantity of 11.4 cu. ft. of screenings removed per million gallons of sewage screened. Fine screening is apparently not necessary for successful operation, but might result in the reduction of the quantity of air required. On account of the large oxygen requirement of Worcester sewage, due to the presence of large quantities of trade-wastes, the reduction would be relatively small.

The results of operation of the small grit chamber indicate that the treatment of combined sewage by the activated sludge process requires careful design and operation of the grit chambers.

Careful records were kept of all temperatures of operation, and it may be stated that winter operation of the activated sludge process in New England climate is generally possible.

The quantity of sludge returned to the sewage was regulated according to the results of a 30-minute settling test of the effluent from the sewage aeration tank, the test being made by reading the volume of settled sludge in a 500 c.c. graduated cylinder.

Foaming occurred in the sludge re-aeration tank during the first 10 days of operation, and it was necessary to raise the tank walls 9 in., and cover the tank with chicken-wire to prevent the foam going over the walls. Foaming occurred at other times, usually with the aeration of activated sludge of poor quality.

Analyses of the air after use in the aeration tanks showed that oxygen was removed and carbon dioxide formed, about 2.1 and 4.3 per cent in the sewage and sludge aeration tank, respectively. A small amount of methane and heavy hydrocarbons was also formed.

The sedimentation period of the aerated sewage and sludge, based on the cylindrical portion of the sedimentation tank, varied from 1.6 to 2.9 hours, which is much longer than is generally considered necessary. This period can probably be shortened, but provision should be made for the continuous removal of reasonably dense sludge, as experience has demonstrated that the return of large volumes of thin sludge to the sewage aeration tank is undesirable. It will also be necessary to arrange for the removal of unsightly grease balls and scum from the water in the sedimentation tank.

Chemical analyses of sewage and final effluent showed a general lack of reduction of free ammonia, considerable reduction of albuminoid ammonia and oxygen consumed, from 85 to 95 per cent removal of suspended solids, about 90 per cent removal of iron, and an entire absence of nitrification of the effluent. Clarification was generally excellent and in the absence of nitrification exerted considerable influence upon the stability of the effluent. Clarification was generally excellent and in the absence of nitrification exerted considerable influence upon the stability of the effluent. The dissolved oxygen content of the effluent usually averaged from 20 to 30 per cent of saturation, but many times was zero in the afternoon.

In general, effluents having less than 0.2 part of total albuminoid ammonia, about 0.05 part per 100,000 of suspended albuminoid ammonia and less than 3.0 parts per 100,000 of suspended solids were of good appearance, but the stability was variable, being influenced by the actual content of organic matter and suspended solids. The effluent usually contained from 50,000 to 350,000 bacteria per c.c. according to the quality, a maximum reduction of 97.5 per cent being obtained when the maximum quantities of air and periods of aeration were used.

Results of Sewage Treatment.—From 75,000 to 125,000 gal. of sewage were treated daily, using from 2 to 5 cu. ft. of free air per gallon and periods of aeration of sewage from 3.8 to 6.2 hours and of sludge, with the exception of one period of six weeks, from 2.8 to 6.5 hours.

1. A total quantity of 1.75 cu. ft. of free air per gallon of sewage, together with 3.8 hours' aeration of the sewage and 3.1 hours' re-aeration of the sludge, using 31 per cent returned sludge, did not remove the color of the trade wastes from average sewage.
2. A total quantity of 2.16 cu. ft. of free air per gallon of sewage, together with 5.3 hours' aeration of the sewage and 5.3 hours' re-aeration of the sludge, using 21 per cent returned sludge and treating weak sewage, gave an effluent having an average stability of about 90 per cent.
3. A total quantity of 1.99 cu. ft. of free air per gallon of sewage, 4.3 hours' aeration of the sewage and no re-aeration of the sludge, using 18 per cent returned sludge and treating very weak sewage, gave an effluent having an average stability of about 60 per cent, but of good chemical quality.

These three statements practically define the treatment of weak Worcester sewage according to the degree of stability desired. Three or four days' stability of the effluent can be obtained without re-aeration of the sludge, when using at least 2 cu. ft. of free air, from 4 to 5 hours' aeration of the sewage and about 20 per cent returned sludge.

4. A total quantity of from 3.3 to 3.6 cu. ft. of free air per gallon of sewage, 6.3 to 6.5 hours' aeration of the sewage and 5.0 to 6.5 hours' re-aeration of the sludge, using about 25 per cent returned sludge and treating fairly strong sewage, gave an effluent having an average stability of about 90 per cent. This result did not always obtain, and the variation or inconsistency is attributed to the character of the sewage.
5. A total quantity of 4.95 cu. ft. of free air per gallon of sewage, 6.3 hours' aeration of the sewage and 5.1 hours' re-aeration of the sludge, using 27 per cent returned sludge and treating hardly average sewage, gave an effluent having perfect stability.
6. The results indicate, but with considerable uncertainty on account of the inability to duplicate, that a total quantity of about 4 cu. ft. of free air per gallon of sewage, 6 hours' aeration of the sewage and 6 hours' re-aeration of the sludge, using about 25 per cent returned sludge and treating average to strong sewage, should give a final effluent of good chemical quality and having a stability of from 75 to 90 per cent.
7. Elimination of re-aeration of sludge while treating average to strong sewage was not attempted on account of the poor results of the second summer and the interruption of operation of the plant.

Summary of Sewage Treatment.—Worcester sewage contains much trade wastes of such varying character and quantity that nitrification did not take place with the quantities of air and periods of aeration used in the operation of the experimental activated sludge plant. A stable effluent was obtained by the reduction of the organic content of the sewage. Lack of nitrification and low dissolved oxygen content of the effluent furnished no factor of safety or stability, such as is usually present in effluents from biological processes of treatment; consequently, sewage of greatly varying character was not uniformly well treated. Increased quantities of air and periods of aeration would probably overcome the sensitive character of the activated sludge process in treating Worcester sewage and give uniformly good results with apparently similar conditions of treatment.

Comparison of Effluents. Activated Sludge and Imhoff Tank-Trickling Filter Methods of Sewage Treatment.—It has been stated that the activated sludge effluent was generally clear, colorless and of good chemical quality but lacked stability. Treating stronger sewage and operating at a rate of 2,000,000 gal. per acre filter daily, the Imhoff tank-trickling filter experimental plant gave an effluent which was generally slightly turbid, slightly colored at times, of greater organic content, but contained about 0.5 part per 100,000 of nitrogen as nitrates, and was perfectly stable during the warm weather, and 75 per cent of the samples were non-putrescible during the winter season.

Sludge Production.—The quantity of activated sludge produced per million gallons of sewage varied from 12,000 gal. in summer to 25,000 gal. in winter; both quantities are much greater than have been produced by any other process of treatment of Worcester sewage. The sludge contained from 97.1 to 98.7 per cent moisture, the denser sludge being obtained in the summer. The dried sludge contained from 50 to 70 per cent of organic matter, from 8.5 to 18 per cent of iron, from 2 to 9 per cent of fats, and from 4.0 to 6.5 per cent of nitrogen. Worcester activated sludge was as dense as that which has been obtained elsewhere, and indicates that it will be difficult to obtain activated sludge, without concentration, having less than 97 per cent moisture.

Air Drying of Sludge.—The greater part of the sludge was dried upon sand beds; this method of disposal is impractical on account of being unable to dose the beds to a depth greater than 4 or 5 in. If more than this quantity was applied, the sludge settled rapidly and water remained on top, which had to evaporate before actual drying commenced. The dose had to be of such size that the bulk of the water drained away during application to the bed; cracking of dried sludge commenced after twenty-four hours, and removal was possible twenty-four hours later. The usual dose was from 2.0 to 2.5 gal. per square foot of drying bed area. Concentration of sludge improved results very slightly.

Concentration of Sludge.—The first step in disposing of activated sludge on a large scale would be concentration, in order to decrease the volume to be handled. Concentration experiments were made in two tanks, one of which was 14 ft. in diameter, 6 ft. deep and held 2,000 gal.; the other was 3 ft. in diameter, 18½ ft. deep and held 650 gal. Heavier sludge could be drawn from the bottom of the deep tank if extremely long periods of concentration were used, but in no instance was sludge obtained containing less than 95 per cent moisture. Concentration of sludge for from 15 to 24 hours decreased the volume of sludge about 50 per cent and its water content from 98 to 96 per cent, the best results being obtained when the sludge was in a flocculent condition. Character of sludge effects the quantity to be handled; that is, poor results of operation as regards sewage treatment may mean increased cost of sludge disposal.

Pressing of Sludge.—A section of a press of the Bushnell type, formerly used for chemical precipitation sludge, was demonstrated to be unsuitable for pressing activated sludge, unless about 2,500 lb. of lime in the form of milk of lime were added to 100,000 gal. of sludge and pressing made for about two hours at 60 lb. per square inch pressure. Without the use of lime, various results of pressing were obtained, depending somewhat upon the character of the sludge; but in all cases radial streaks of soft sludge were formed which rendered the press cake unfit for disposal. Our present installation of sludge presses is unsatisfactory for handling activated sludge without preliminary treatment. The results indicated that the successful press should de-water the sludge to about 70 per cent moisture during the first 20 to 30 minutes of operation, and the addition of lime should not be necessary.

Sludge as Fertilizer Material.—The nitrogen content of activated sludge is greater than that of any other sewage sludge at Worcester. Fertilizer analyses of activated sludge, Imhoff tank and final settling basin sludges are given as follows, the results being percentages and given in the above order.

Substance.	I	II.	III
Total nitrogen	4.06	2.61	2.42
Available nitrogen	1.39	1.25	1.71
Total phosphoric acid	2.26	1.66	3.43
Citrate insoluble acid	0.50	0.46	1.16
Citrate soluble acid	1.76	1.20	2.27
*Potash.			

*Not determined, varies from 0.0 to 0.05 per cent

The available nitrogen in the Imhoff tank sludge is but little less than that in the activated sludge, while the final settling basin sludge contained considerably more than did activated sludge. The final settling basin sludge also contained much more total and citrate soluble phosphoric acid than did activated sludge. The actual nitrogen content of activated sludge as compared with combined Imhoff tank and final settling basin sludge, based on unit quantity of sewage treated, is approximately 2½ times as great. If revenue was desired along these lines, facilities would have to be provided for handling six times as much unconcentrated and three times as much concentrated activated sludge as of the combined sludges, and about one and one-half times as much dry solids.

Summary.—The operation of the experimental activated sludge plant for a period of 13 months demonstrated that this process of treatment of Worcester sewage will produce an effluent of excellent appearance and good chemical quality. The quantity of air required was much greater than that which has been considered possible to use in other cities. This increased air requirement is due in great part to the necessity of reducing the organic content of the effluent to a relatively small quantity in the absence of any nitrogen as nitrates, in order to obtain a stable effluent. The problem of disposal of large volumes of sludge each day was only partially solved, but it was demonstrated that our present sludge press installation was not suitable for handling activated sludge.

The Net Duty of Irrigation Water*

By PROF. W. L. POWERS,
Chief in Soils, Oregon Experiment Station, Corvallis, Ore.

By net duty is meant the quantity of water required to be delivered to the field or the forty.

Water requirement is a term used to refer to the total soil, rainfall, and irrigation water required per unit of crop, and is conveniently expressed in "pounds of water per pound of dry matter" in crops produced.

Irrigation requirement refers to the irrigation applied artificially to meet the water requirement of the crop.

As to standards for judging the terms we may consider, first, the yield per acre which is best in a new country; second, the yield per acre-inch or per acre-foot which is a valuable standard for judging results where water is high in cost, as where pumped, and which is best for showing the efficiency per unit of water; third, the maximum net profit per acre which is regarded as the best present basis for determining the economic duty of water. Maximum net profit per acre is realized with more water than is required to give the maximum yield per acre-inch, but with a little less water than is required to give the maximum yield per acre. Where costs are high the maximum net profit draws closer to the quantity required to produce the maximum yield per acre-inch, so it allows for beneficial use according to conditions, all costs considered; further, it makes possible the highest productive values.

Modern irrigation contemplates that the water be measured. This lessens contention, dispels doubt, and increases duty. The amount of water at present used does not necessarily indicate the amount needed, yet it shows what farmers are getting along with in practice, and the difference between the amount used and the indicated net duty shows the amount of possible improvement. The use on about 1,000,000 acres included in the United States reclamation projects reported by Moritz in the Reclamation Record† shows that the amount used during the past six years has been materially decreasing.

Average depth applied in 1918 on [illegible] Government projects was, feet	2.75
Range, feet	0.68-6.30
Average rainfall, feet	0.82
Total water received, feet	3.57
Average per cent of alfalfa and other meadows for these projects was	52.5
Average per cent of alfalfa and other grain	22
Average per cent of alfalfa and other cultivated and miscellaneous crops	25.5

Alfalfa and meadows occupy 50 per cent of the irrigated area and require, roughly, about twice the amount of water as other crops, such as grain and row crops need, hence, merit 75 per cent of our attention, as they require 75 per cent of the irrigation water.

Water variation experiments on alfalfa afford data for each of eight states. The indicated economic duty or amount giving the indicated maximum net profit runs from 30 to 40 in., where yields are from 4 to 9 tons, or 0.12 to 0.20 ton per acre-inch. Based on 12 years' water requirement studies at Corvallis, Ore., and on the average water requirement which in each year gave the maximum net profit, it takes 5.23 in. under field conditions per ton of alfalfa produced, or 0.166 ton per acre-inch. On this basis it would take 15 to 18 in. depth of irrigation for a 3-ton region, or 30 to 36 in. for 6-ton land.

Grain crops require less water. In the water variation trials on wheat carried on for six states the irrigation requirements ran from 13 to 24 in. in depth, the yield amounting to 15 to 55 bu. and under good conditions up to 3 bu. per acre-inch. In other words, fairly efficient use of the water is being secured where 3 tons of alfalfa are secured with 15 to 18 in., or 36 bu. of wheat with 12 in., or 300 bu. of potatoes with 12 in. depth of irrigation.

Factors Affecting Farm or Field Duty.—The kind of ditches or distributaries affects the loss in delivery on the 40. They should be large enough to permit rotation in use and of compact section; 10 to 15 per cent of waste below the turn-out is allowable under present conditions.

Careful preparation of the land by thorough leveling to one or more planes will save time, money, and water.

The method of applying water affects the irrigation requirement. The head and length of run should be such that the plot irrigated can be covered by the time the irrigation has wet the root zone. In many of our valleys the flooding system is being improved by the introduction or extension of the strip-border method of flooding and by determining the proper length and width of strips.

Climate affects the duty of water. Evaporation records are as important as rainfall, as they give a collective measure of the drying influences of the weather.

Altitude as related to climate affects the duty. If the loam soil in eastern Oregon requires about 3 ft. up to a 2,000-ft. elevation, 2 ft. is a reasonable depth of irrigation at a 3,000-ft. elevation and 1½ ft. is suitable for a 4,000-ft. elevation.

Soils, their texture, depth, structure, or, collectively, their usable water capacity affect duty. Our coarsest irrigated sand has a usable water capacity of about two-thirds of an acre-inch per acre-foot; for fine sand, 1 in. per acre-foot; fine sandy loam 1¼ to 1½ in.; very fine sandy loam 1½ to ¾ in.; silt loam 1¾ in.; silty clay loam approximately 2 in. per acre-foot. Some of our peaty loam soils have usable water capacity of 2 to 3 in. per acre-foot as determined by the cylinder method under field conditions.

Duty is affected by the kind and variety of crops. Meadows require much water, grain crops and peas require a moderate amount, and cultivated crops, such as potatoes, require still less.

The average yield up to a certain limit represents to some extent a ratio between the quantity of crops and the quantity of water required. The average yields under good modern methods of farming should be considered in determining duty.

The kind and amount of cultivation affect greatly the irrigation requirements.

The method of delivery affects the use of water and this conforms as nearly as possible to plant needs. A higher duty may be obtained where the irrigator pays at least maintenance charge in proportion to the actual amount of water used.

The skill and economy of the irrigator are important factors. During irrigation the irrigation farmer is worth more in manipulating his irrigation and watching it than he is on any other work ordinarily done on the farm.

The time of irrigation affects greatly the efficiency of the water applied. The whole purpose of irrigation is to provide a favorable moisture content. In the Oregon experiments the moisture was applied according to the moisture content of the soil. It was found that as much as 50 more bushels of potatoes could be secured by applying water at just the right time.

The amount of water applied at each irrigation affects the use of water. It should be sufficient to raise the moisture content to the excess point throughout the root zone.

Soil fertility is one of the most important factors affecting irrigation requirement. With good fertility the plant does not have to exert as much effort to secure the nourishment required to form a pound of dry matter. For example, with potash as fertilizer we have obtained 39 bu. of potatoes per acre-inch, whereas an unfertilized adjoining acre returned only 24 bushels per acre-inch. Applications of sulphur have increased the efficiency of water per acre-inch about 25 per cent on several Oregon irrigation projects. About 16,000 acres of alfalfa have been sulphured in the state. Experiments have proved that applications of 80 to 100 lb. of sulphur per acre once in four years will increase the yield at least a ton per acre per year on 200,000 acres of alfalfa land under irrigation in the more arid sections of the state.

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*From the Reclamation Record, April, 1921.

†Reclamation Record, March, 1920, page 128.

Crop diversity is important. A cultivated cash crop which requires little water generally gives large cash returns per unit of water consumed. Such a plan also involves distribution in the use of water on irrigated lands.

Crop rotation is of more importance to the irrigation farmer than to the rainfall farmer. As large irrigated crops generally remove large amounts of fertility, equally large amounts of refuse should be returned to the land. Rotation permits plowing up of the meadows and marketing the nitrogen accumulated by the legumes; and plowing increases the usable water capacity and liberates plant food.

The value of crop rotation and manure has been tested by the Oregon station. In a recent experiment covering two 3-year rotation cycles beans were grown continuously in comparison with beans in rotation with grain and alsike clover. The upper half of each half-acre plat was dry farmed and one side of the half-acre was manured. The three crops were represented in the experiment each year. Beans grown continuously for six years yielded under irrigation 10.21 bu.; with irrigation and rotation the beans grown on alsike clover sod yielded 15.49 bu., and beans rotated and manured yielded 18.25 bu. The yield per acre-inch was 4.8, 6.16, and 7.3 bu., respectively. The average yearly net profit due to rotation under irrigation was $11.72, which was increased with manure and rotation to $21.50.

The net profit per acre-inch for beans grown continuously was $6.84, grown in rotation $11.52, and grown in rotation with manure plants $15.44, showing the great value of rotation and manure in increasing the efficiency per unit of water employed. The water requirement per pound of dry matter with continuous cropped beans was approximately 2,500 lb., in rotation, 1,700 lb., and with rotation and manure 1,300 lb. Beans give a moderate amount of dry matter per acre, hence the water requirement of this crop is rather high.

CROP-PRODUCING POWER OF WATER.

(Based on an average water cost of most profitable plot records under field conditions, showing least probable amount of water (acre-inches) likely to be needed for different yields.)

ALFALFA.

Yield per acre. Tons.	Acre-inches required.
1	5.23
2	10.46
3	15.69
4	20.92
5	26.15
6	31.38
7	36.61

CLOVER.

Yield per acre. Tons.	Acre-inches required.
1	3.84
2	7.68
3	8.54
4	12.81
5	17.08
6	21.35
7	25.62

GRASS.

Yield per acre. Tons.	Acre-inches required.
1	4.27
2	8.54
3	12.81
4	17.08
5	21.35
6	25.62
7	29.89

BEETS.

Yield per acre. Tons.	Acre-inches required.
5	2.5
10	5.0
15	7.5
20	10.0
25	12.5
30	15.0
35	17.5

POTATOES.

Yield per acre. Bus.	Acre-inches required.
50	1.5
100	3.0
150	4.5
200	6.0
250	7.5
300	9.0
400	12.0

The water cost or water requirement per pound of dry matter is reduced by most farming operations that improve the tilth and soil fertility and by having a good, even stand of the best variety, seeded, cultivated, and irrigated at the right time. Similar factors affecting evaporation or percolation have a bearing on duty. However, water requirement is a technical measure of the efficiency secured for each unit of water. Based on the water requirement in the western Oregon experiments, it has taken 5.23 in. to produce a ton of alfalfa, 3 in. to produce 100 bu. of potatoes, and one-half inch to produce a ton of beets.

In arriving at a reasonable duty of water we must take into consideration the value of land, water, labor, and crops for the district. At present, in the Northwest at least, the maximum net profit per acre seems the best basis for judging economical use of water.

Operating a Waterworks Plant Under State Supervision

Privately owned waterworks plants in Illinois have been subject to state supervision for the past eight years now, and there is a considerable discussion as to whether state supervision should be abolished in favor of so-called home rule. C. M. Roos, secretary Cairo Water Co., Cairo, Ill., thinks that the utilities should take the public more into their confidence. In a paper read by him before the recent annual meeting of the Illinois and Iowa Sections of the American Waterworks Association, he gives his views as follows:

Discussion of this utility regulation question by those who advocate "home rule," has brought forth expressions from various interests and classes throughout the entire state, which appear to be largely in the majority, favoring a continuation of state regulation as opposed to home rule.

Regulation of Public Utilities.—Few questions in Illinois at present are attracting as much attention from commercial organizations, business men, bankers, professional men, municipal authorities and labor organizations as this one of regulation of public utilities. In all of the discussion little has been said publicly by the utilities themselves. It is obvious why there should be hesitancy on the part of the utilities in going on record in a discussion of this character, because past history proves that there is a tendency on the part of the public to look upon statements by public utilities with a certain suspicion, and not to accept them in the good faith which should exist if co-operation and best results for all interests concerned are to be obtained.

But have we not reached the time when common sense, good business for all concerned, and the best interests of the general public demand that the experience, opinions and advice of public utilities be heard in the discussion of this and other similar utility questions which vitally affect the public? Certainly no other interests are better qualified to participate in the discussion of public utility problems than the public utilities themselves.

Utilities to Blame for Lack of Public Understanding of Their Problems.—The woeful lack of intelligent understanding on the part of the general public of some of the vexing utility problems of today is largely because the utilities have hesitated frankly and openly to discuss these problems and to take the people into their confidence.

This entire situation is largely due to the attitude which the utilities have taken toward the general public. Utilities have not talked to the people as freely as they should. The utility business is the most vital business in any community, having a more direct bearing on the community welfare, progress and convenience than any other class of industry. There are few classes of business more dignified and contributing more to the comforts and welfare of man and which are today operated in better faith than the public utilities. Utilities have much to talk to the people about, many interesting and vital things about the business to explain, and the sooner the general public knows the real facts about the utility business, coming frankly and in good faith from the utilities themselves, the easier will it be, wisely and successfully, to solve some of the problems with which we struggle today.

If the public really knew conditions as they exist today in the public utility business there would be little difficulty in solving our utility problems, the utilities would be in a position to do financing to better advantage, confidence in utility securities would not be shaken and utilities would be in a position to make needed improvements and extensions, all of which would be directly to the advantage and interest of the consumers and would contribute directly to community development and the re-establishment of general business confidence.

How to Conduct a Public Utility Educational Campaign.—Public utility educational campaigns are needed and the burden of conducting them rests upon the shoulders of the utilities. Is it not true in practically every community that the public criticises and openly attacks its public utilities more freely than any other class of industry within the community, and yet only a very small percentage of the citizens of a city will ever take the time and enough direct interest in their utilities even to visit the plants, see how the work is done or talk with the managers and learn first hand some [illegible] latter they should kn[illegible] [illegible] part [illegible] community life and ex[illegible]

[illegible] public utility educational [illegible]

1. Interesting members of commercial organizations, city [illegible] women's clubs and [illegible] in making careful inspections of the [illegible] visits should be made in groups and instructors at the plants should explain details of operation [illegible].

2. When at all practical local citizens should invest financially in their local utilities. The people themselves can do much to make their utility investments the safest and most desirable to be found, and [illegible] will not only profit financially directly from their investment, but indirectly in service rendered by the utilities and in the ability of the utilities to keep pace or set the pace for community development and expansion.

3. Local boards of education should be led to see the importance and necessity of having pupils of all grades in the public schools study their local utilities. In most cities the utilities could provide lectures, periodically to the school children, and also to the school instructors who, in turn, could teach the subject in connection with their regular class studies.

4. Newspaper advertising in the form of heart to heart talks with the people. Enclosure slips in local mail telling the consumers about their utilities.

5. It should be known in the community that questions and complaints or criticism about service, etc., are solicited by the utilities instead of discouraged, so that consumers will not hesitate to go direct to the utilities about any matter in connection with their business in the community.

Education of Public Along Three Lines.—Education of the public should be along three distinct lines, viz.:

1. The people should take a real and direct interest (financial if possible) in local utilities, familiarizing themselves with the business to the extent possible.

2. To select capable, well qualified men to represent them in their government, local and otherwise, regardless of political affiliation and to trust to the judgment of experts in deciding questions of a technical or professional character.

3. To be less hasty in openly criticising constituted authority unless or until the basis for criticism is well and intelligently established. Unless the attitude of our American people toward constituted authority changes it will soon be difficult to persuade highly qualified men to serve in public office. Lack of confidence in constituted authority destroys the very basis of sound government and the results are evident on every hand.

We are living in an age when the people demand control and rule as never before. The rights of the people must be defended and preserved, as this is a country of and for the people, and no one has any authority whatever, civil or otherwise, to deprive any citizen, who respects the laws established by the majority, of his rights as a citizen. But rule or control or regulation by the people does not mean that safety, economy and efficiency in all channels of civic and industrial activities can be secured by direct supervision or regulation by the masses, who can not be expected to be qualified to pass wisely on all phases of community life and industry. Thus the judgment of a doctor of medicine would scarcely be good in deciding a technical question in connection with the regulation of a waterworks. The same can be said of many other classes of citizens without in any sense reflecting upon their intelligence.

Waterworks Business Must Be a Monopoly. The waterworks business is unique in many respects as compared with private industries. It is by nature a monopoly in its community which it serves. It is to the interest of both the consumer and the operator that it be a monopoly. Duplication of investments in public water supplies in any city invariably results in the necessity of finally consolidating the systems, thus throwing upon the consumers the burden of supporting a larger investment than would otherwise be necessary.

A waterworks is unique in that the investment in it is or should always be of a permanent character. The very nature of the business requires this Our limited franchise (a relic of Illinois home rule) prevent economical financing of permanent investments in waterworks and also prevent private utility corporations from installing in communities as high type equipment as otherwise could be provided. Attempts by local communities to fasten upon water works utilities from [illegible] contracts in the form of franchises, and at the same time demand immense investments in equipment, the protection of which depends directly upon the bargaining again at the expiration of the franchise with local authorities who though otherwise intelligent men have no technical knowledge of waterworks and cannot be expected to have, cannot but result in working havoc at no distant date. The truth of this will certainly soon dawn upon many cities much to their sorrow.

A waterworks plant is unique in that it is expected to operate continuously whether costs of supplies are high or low, regardless of labor troubles or transportation difficulties whether the business is profitable or not, whether the company's credit is good or bad, and when repairs are difficult and expensive to make on account of inability to cease operations for a period. In addition to all of this the plant is supposed to be operated on the basis of a bare legal interest rate of return on its investment as its maximum return, with no guarantee against losses. No profit is supposed to be figured in waterwork business. An interest rate of return on an investment in an industry cannot be considered as profit. To insure holding the return to utilities at the rock bottom or below, the public stands by dictating the rates to be charged for service.

Private Industry and Waterworks Business.—Now in contrast with a waterworks plant, note that a private industry has the sky as its limit for profit and when business is bad it closes its doors and lays off its employes, thus cutting down expenes. It ceases operations at will to make repairs at ease and economically. Its machinery and equipment usually operate only about 8 or 9 hours per day and 6 days per week, which gives the mechanical department ample opportunity to do emergency work to good advantage. It markets its securities to much better advantage than a water company possibly can. It has an unlimited field for development. Finally, it is its own boss in the sense that it has no public regulation of its rates or prices for its products.

These statements as to conditions under which a waterworks utility must operate as compared with a private industry is true in a sense whether it is under state regulation or home rule. In both cases it is public regulation by the people. The question under discussion by so many in our state is which method of regulation is to the best interests of all concerned.

Public Utilities Must Be Regulated.—The public utility business by nature should be and must expect to be subject to public regulation. The only real fault or complaint along this line which utilities should file is that it is discriminatory and grossly unjust that the public should "regulate" utilities, which mean keeping profits down to rock bottom and far below in many instances and at the same time not "regulate" the control of the state's natural resources and necessary commodities upon which utilities must depend to operate their plants.

Public control of utilities and failure to control the business which furnishes utilities with necessary operating supplies has resulted during the last few years in the utilities' already deflated purse becoming leaner and leaner, with the contents of same filling the purse of private industry in enormous profits. The State Public Utilities Commission is not at fault in this. The fault lies in the provision by our government for regulation of one class of business while another class is earning large profits from money from the first class, all unmolested, because no authority has been provided to regulate certain private industries.

This discussion is not presented for the purpose of registering an objection on the part of a public utility against public control of its business. Its object in part is to state that both home rule and state regulation of utilities are controlled by the people, of which control so many are jealous. Its object further is to call attention to the fact that the general public does not realize that the public utilities have suffered enormously in depleted earnings and heavy losses during the last few years, when other industries were growing fat, and that the small increases in rates authorized from time to time recently by the State Public Utilities Commission were absolutely necessary in practically every case to barely keep the utilities alive.

A Few Facts the Public Should Remember.—The people of Illinois do not appear to remember that from Jan. 1, 1913, to Jan. 1, 1917, the State Public Utilities Commission lowered rates for utility service throughout the state to the extent that over $5,000,000 was saved to the consumers during that period.

The general public apparently does not realize the tremendous significance of the fact that during the last few years the increase in the cost of money to the public utilities has been three times that to manufacturing industries, and that the only way capital can be secured for our utilities is in the open market in competition with these other more attractive securities.

Our people fail to realize the significance of the fact that in the United States today the investment in public utilities, exclusive of railroads, amounts to approximately $15,000,000,000, of which about $1,250,000,000 is in Illinois, and that this immense investment has not been made by a favored few, but by the people themselves who hold utility securities. In Chicago alone $565,000,000 is invested in utility companies, being more than twice as large as Chicago's investment in its own utilities. These figures represent book value. Reproduction of our utilities as of today would show a much larger investment than is indicated by these figures here submitted.

The general public does not realize that it is benefited directly and otherwise more by the capital invested in its public utilities than in any other enterprise within its borders, yet the tendency on the part of the public generally is to abuse or fail to appreciate capital invested in its utilities more than in any other industry.

Those who are opposing state regulation do not know the great value and importance of having uniform systems of accounting, well-established standards for service, equipment, etc., for all the utilities in force throughout the state, all of which have been brought about by state regulation and which cannot be provided or maintained otherwise.

The general public is woefully ignorant, indifferent or forgetful of all of this, largely because the utilities have failed to talk frankly to the people as they should.

While the public utilities as a class have hesitated to go on record in expressing an opinion about state regulation, yet it is a fact that many utilities have chafed under the apparent delays in securing absolutely necessary relief through the State Utilities Commission, and when relief would finally come it would often be inadequate to provide for increases in operating costs subsequent to the time when applications for increased rates were filed.

State Regulation Necessary.—We as utilities must realize the fact that the State Commission has been dealing with a public sentiment invariably strongly prejudiced against public utilities, which made it difficult for the people to understand the absolute necessity and justice of increased rates for service. The commission, a representative of the people, has the people to consider as well as the utilities. Few of our communities realize as we utilities do that they owe the State Public Utilities Commission a real debt of gratitude for having tided the utility business of the state over the most dangerous and difficult period in history, when commodity prices soared from 100 to 300 per cent above normal, and at the same time holding rates for utility service down to a very small fraction of this increase in general commodity costs.

Though the utilities have suffered greatly during this difficult period, it is a remarkable fact that our state regulatory body has handled the situation without a single case of a utility ceasing to function.

Rates for service seems to be the point around which practically all criticism of state regulation on the part of the general public centers. Illinois has no reason to complain about its utility rates for service, particularly about water rates. The average highest rate for water in Illinois is 30.4 ct., and the average best commercial rate is 13 ct. per 1,000 gal., as of Jan. 1, 1921, which is considerably lower than the average rates in other states.

Confidence in utility investments must be restored. The interests of the public will best be served by having it so, regardless of the direct effect it may have on the utilities themselves.

Regardless of the attitude of the public utilities toward state regulation, anything less than state regulation of our utilities will mark the complete collapse of the market for utilities securities and thus destroy the very foundation and framework of our entire economic structure.

A 30,000 H. P. Development in Northern Ontario

Work has been in progress for about a year on a new power development at Twin Falls, on the Abitibi River in Northern Ontario. Twin Falls is located above the townsite of Iroquois Falls where the mills of the Abitibi Power & Paper Co. are located. The purpose of the development is to provide increased power for these mills and will approximately double their present output of 200 tons of paper per day. A description of the project and also the construction plant was contained in a recent issue of The Canadian Engineer in an article by Col. Harold L. Trotter, Resident Engineer, and the following abstract is of interest.

The natural head available at the site of the dam was only 1.5 ft., but the dam will raise the head to 57 ft. and provide from 25,000 to 30,000 HP. during low-water periods. Five 6,000 HP. units are included in the design.

The development involves the construction of a main dam across the river, with three submerged openings, two Stoney sluices, core walls extending into the banks on each side of the river, and a powerhouse on the west side.

The powerhouse is of reinforced concrete, with heavy pilasters carrying the crane beams and roof trusses. It is divided into two main parts—the generator room, 178 by 40 ft., and the gate house, 162 by 30 ft. There is an intermediate room between these two, above the batter of the breast wall, which is used as the high tension room and offices.

The dam is of gravity type, 360 ft. long, with overflow crest at elevation 881.63, local datum. A foot bridge 4 ft. wide, is provided over this, supported on piers 2 ft. wide, set 30 ft. center to center. The crest of the dam is heavily reinforced to withstand ice pressure.

The three submerged sluices have 7 by 7-ft. clear openings, with sills at elevation 810. They are protected against driftwood and other obstructions by a coarse rack. The discharge from the openings is controlled by steel gates which slide in checks provided for the purpose.

The gates were supplied by the Coffin Valve Co., and are operated by a screw stem and gate hoist. The hoists are located in chambers opening off a passage in the middle of the solid dam. Access to the passage is had through a tunnel leading from the powerhouse floor.

The Stoney sluices have 40-ft. clear openings, with sills at elevation 859.5. The gates have the usual elevating gear and towers, and they slide up and down on roller trains. In addition to the Stoney gates, each opening is provided with checks for emergency stoplogs, and one set of stoplogs will be kept in the stoplog storage house beside the piers. The stoplogs consist of two 24-in. I-beams riveted to a skin plate on one flange and latticed on the other flange, forming a box girder. The logs vary in height according to their place in the gate, the bottom log being 14 in. in height, and the top one 3 ft. 6 in. Wooden inserts are arranged on the web to make water-tight contact between logs.

On the east side of the river the dam is carried a distance of 360 ft. into the clay hillside, in the form of a concrete core wall, 4 ft. thick. The top of the concrete is at elevation 882.63, and this will be covered over with earth fill to elevation 887, and the embankment will be sloped, back and forward, with 1 in 3 slopes, paved with rubble.

A similar core wall is being built on the west side, from the powerhouse westward about 300 ft., and from there on, 450 ft. of sheet steel piling will be driven to rock.

It was found, as the core-wall excavation progressed, that the rock dropped away below elevation 800. A very careful survey was made by means of wash borings, and it was decided to carry on the concrete as a 4-ft. concrete wall on rock to the end of the 300 ft., and from there on to drive steel sheet piling to rock. Afterwards, by tunneling from a shaft, it is intended to place a substantial toe of concrete behind the piling on the rock. This precaution was decided on, owing to the saturated condition of the sand stratum overlying the rock.

The sheet piling purchased for this work is in 30-ft. lengths and has to be spliced to three lengths to reach rock, which is from 90 to 110 ft. below surface level along the line selected.

Backfilling, with 1 in 3 slopes, will be placed over the top of the core wall and piles when completed.

As most of the pulpwood for the mills at Iroquois Falls is [illegible] above the dam site and [illegible] log-sluice has been provided at the [illegible]. At the entrance the log sluice is [illegible] it narrows to 4 ft. at the discharge, as the velocity of flow in the chute increases.

The water wheels consist of five 6,000-HP. single runner vertical turbines running at 1,285 r.p.m. Power is generated at 13,000 volts, and transmitted to Iroquois Falls and 300,000 c.m. stranded copper wire set on towers 400 ft. apart.

The transportation equipment on the river consists of a tug, three scows of 120-tons capacity, and one scow of 40-tons capacity.

The river trip is 21 miles, and takes about 6 hours to perform. At Matheson, a siding was built from the T. & N. O. Railway to the dock, about one-half mile. The docks existed before work was started but had to be much improved before trains could run out on them. Cars are spotted by the T. & N. O. Railway on the dock, and the material is unloaded onto the scows. A 12-ton derrick was set up for the purpose of moving machinery from the cars to the scows.

At the power site, ample dockage convenient to the work has been provided for unloading.

At the site where the dam is being built, the river was only some 140 ft. in width, and the rock banks rose sharply about 20 ft. on either side. The first problem was to provide a means of deflecting the river flow during construction. To do this and to provide rock for filling cribs and for concrete aggregate, a cut was made on the east side 100 ft. wide, at elevation 822, i. e., 1 ft. below tailwater.

The base of the dam and piers for four sluices, each 20 ft. wide, were then built in this section and provided with stoplog checks. The sills and piers for these sluices conform to the section of the dam, so when the final closure is made the whole will be embodied in the dam.

In the first instance it was intended to use crushed rock and sand for the concrete aggregate, the rock to be taken from excavations and quarries at the site, and the sand to be obtained from a pit on the river bank about three miles above the work.

The crusher, an Austin gyratory No. 5, was on the ground when the work was taken over, and this was set up and operated in April and May. After the snow had gone, however, a gravel bed of ample quantity and excellent proportions was discovered not far from the original sand pit, and the consent of the consulting engineer was obtained to use this without the addition of crushed rock.

The concreting plant consists of two 1-yd. Smith mixers. They are charged by means of Smith batch-charging hoppers, which in turn are filled through gravity chutes from storage bins. The mixers are set up with twin towers 120 ft. high, and the Ransome No. 36 buckets, which carry the concrete up to the towers, discharge inwards so as to use the same discharge hopper. This makes a very flexible system, for, by having two hoppers at different elevations between the towers, either one or both mixers can be used for either hopper.

The chutes employed are wooden, rectangular in shape, with 8-in. sides, 12-in. bottom, 1½-in. chamfer in corners, and lined with sheet iron. These chutes are supported on A-frame trestles on a 4-in. per foot grade. A walkway and handrail are laid at one side of the chute.

Short lengths of swing chutes or concrete buggies are used for distributing concrete in wall forms.

To cross the river where intermediate support could not be obtained, the chutes were slung on cables. Owing to the sag in the cables, the grade was increased to 5 in. per foot, which proved entirely satisfactory.

Gravel is excavated from the gravel pit by means of a 10-ton Marion steam shovel. It is loaded onto a train of six 4-yd. cars, and thence it goes by rail ¾ mile to the river bank. The cars are dumped at the chute and the gravel runs by gravity to its place in the storage pile. Two trains are employed on this line, with a through siding near the upper end for passing. By this method a train load is dumped to the storage pile every 20 minutes.

The track at the dumping chute is 90 ft. above the river level, and the gravel slides by gravity to a 1-yd. clam, which [illegible] carry a load of from 120 to 140 yd. each, and are towed by tug from the point of loading to the gravel wharf, about three miles. Here the scows are unloaded by a clamshell derrick into 5-yd. dump cars. These cars are hauled up an inclined trestle to dump to storage or into the hopper which feeds the car serving the mixer bins.

The screening of the gravel for different classifications of concrete is done progressively. At the point where the trains dump gravel to the cars, the large stones down to 6-in. are screened out by an inclined grizzly of light rails. There is another similar screen, with bars 4-in. apart, at the unloading plant, and at the storage bins above the mixers is the final adjustable screen that can be altered according to the requirements.

The total force employed on the work is from 500 to 600 men. The work is being done under contract by Morrow & Beatty, Ltd., engineering contractors, of Peterborough, Ont., under the supervision of W. B. Crombie, representing Geo. F. Hardy, consulting engineer, of New York City. T. A. Barnett, formerly of the Ontario Hydro-Electric Power Commission's construction department, is the contractors' superintendent on the work.

Conveyance Losses of Water on U. S. Reclamation Service Irrigation Projects

A knowledge of conveyance losses in canals is of transcendent importance to the irrigation engineer; but notwithstanding this, it has probably received less study and investigation than less important factors bearing upon irrigation practice and engineering. The quantity of water lost in transit is enormous, and in some cases appears to equal and even exceed the quantity delivered to the lands. Useful information on this subject is given by Mr. E. A. Moritz, former project manager, Flathead (Indian) Project, Montana, in the April Reclamation Record, from which the matter following is taken.

Seepage Losses on U. S. Reclamation Projects.—It is not so difficult to estimate the total losses from an irrigation system, although it involves more elaborate or extensive records, as it is to estimate the probable losses from canals in different materials, and the variation is not so large. Both classes of records have been kept on projects of the United States Reclamation Service. Table I shows the percentage of water lost on the several projects for each year from 1912 to 1918 inclusive. A considerable variation is noted on most of the projects in the percentages of water lost in the different years. Some of the variations show a rather erratic tendency at times. For example, the North Platte project shows a loss of 66 per cent in 1915, whereas the next highest loss is only 47.2, and the average for all years is 43.6. It is difficult to believe that the loss could have been so much higher in 1915 than in any other year. The average is probably very close to the truth, but the yearly figures may or may not be. The same is true on other projects.

Variation in percentage of losses from year to year must be expected. The projects are nearly all in process of development and conditions are continually changing; new canals and laterals are built and larger quantities of water carried perhaps through longer distances. Another factor that may have considerable effect is the cleaning of silt deposits from the canals. When an extensive job of this kind is done the following season is very likely to show a considerable increase in the losses.

The large variation in the losses between projects is difficult to understand without a knowledge of the projects. The small indicated loss on the Uncompahgre project of 6.1 per cent is explained by the fact that most of the canals act as collecting channels for seepage and waste water from canals higher up. This frequently results in a net gain to the canal rather than a loss. The percentage loss includes the gains as well as the losses. The small indicated loss on the Rio Grande project results from the fact that the losses shown are for a few trunk canals only. In 1918 the losses were taken on many additional canals, hence the large increase indicated in that year. On all other projects the figures include losses in all canals and laterals.

If the Rio Grande and Uncompahgre projects are excluded, the lowest indicated loss is on the Tieton project, Washington, which shows a mean of 24.3 per cent. The highest loss is 53.2 per cent for the Carlsbad project, New Mexico. The average loss for all the projects, exclusive of Rio Grande and Uncompahgre, is 36.1 per cent. From this it is fair to as-

TABLE I—SEEPAGE LOSSES IN U. S. RECLAMATION SERVICE. IRRIGATION PROJECTS.

Project.	Total losses (per cent) 1912.	1913.	1914.	1915.	1916.	1917.	1918.	Mean.	Predominating soil.
Salt River	40.0	40.0	42.7	40.0	43.3	43.7	45.9	42.2	Sandy loam and clay.
Yuma	34.1	32.0	27.7	20.0	27.4	25.3	23.2	27.1	Rich alluvium.
Orland	20.0	26.5	26.0	27.3	20.5	27.3	33.1	25.8	Sandy loam, silt and gravelly loam.
Uncompahgre	1.8	5.1	7.6	12.4	2.2	2.9	7.7	6.1	Red sandy gravel, adobe and clay loam.
Boise	45.5	33.9	34.8	37.1	34.8	35.8	35.1	36.7	Clay loam and light sandy loam.
Minidoka:									
North Side gravity	26.0	22.6	25.0	36.3	43.9	48.9	41.4	35.2	Sandy loam, clay loam and volcanic ash.
South Side pumping	35.1	32.9	35.1	36.3	38.8	36.6	35.6	35.8	Sandy loam, clay loam and volcanic ash.
Huntley	16.2	21.6	28.6	41.3	40.3	48.9	47.5	34.9	Clay and sandy loam.
Milk River	42.8	32.7	40.8	61.4	38.5	41.4	35.3	41.8	Sandy loam, clay and gumbo.
Sun River	20.0	38.1	39.7	41.8	41.9	37.6	40.3	37.1	Sandy loam, clay, adobe and alluvium.
Lower Yellowstone	43.0	52.0	52.4	43.1	47.9	42.8	46.9	46.9	Sandy loam and gumbo.
North Platte	38.7	38.4	36.8	66.0	40.7	47.2	37.7	43.6	Sandy loam.
Newlands	39.8	36.7	29.9	41.2	29.9	32.2	38.0	35.4	Sandy loam, clay and volcanic ash.
Carlsbad	48.0	54.5	55.5	48.6	58.5	57.2	50.1	53.2	Pecos sandy loam; large lime content.
Rio Grande	..	6.8	2.7	5.1	6.5	3.7	14.9	6.6	Rich alluvium.
Umatilla	27.8	27.4	40.1	43.8	36.5	24.8	32.2	33.2	Sandy loam.
Klamath	36.1	39.8	40.1	50.3	49.1	41.5	40.4	42.5	Disintegrated basalt, volcanic ash.
Belle Fourche	31.7	40.2	43.6	31.1	15.7	31.5	32.6	32.3	Clay and sandy loam.
Okanogan	47.1	38.4	21.1	24.1	22.2	20.4	33.7	29.6	Volcanic ash, sand and gravel.
Yakima, Sunnyside	26.7	25.8	28.4	31.2	26.2	26.8	23.4	26.9	Sandy loam and volcanic ash.
Yakima, Tieton	16.6	21.4	27.2	27.4	27.3	26.2	27.8	24.8	Volcanic ash.
Shoshone	36.4	36.5	37.2	35.1	34.9	41.8	37.7	37.1	Light sandy loam and clay loam.

sume that 25 per cent is about the minimum loss that may safely be assumed under favorable conditions and that 50 per cent is sufficiently high for a well-planned project under unfavorable conditions.

It is commonly accepted as a fact that the seepage losses from canals decrease as time goes on and the banks become more compact and the interstices become blinded with silt. The figures given in the table do not show such a tendency. However, this does not prove the absence of such tendency generally because, as has been stated, the change in percentage of lost water from year to year is affected by new construction, variation in total quantity of water used, and maintenance work. But in some cases the absence of a tendency for canals to become tighter with continued use is clearly indicated. The Sunnyside project, Washington, is a good example. This shows a loss in 1912 of 26.7 per cent. No reduction in this figure is shown after six years' continued operation. In fact, the average loss for the years 1912 to 1918, inclusive, is 0.2 per cent higher than the loss in 1912. The losses were little or not at all affected by the factors above mentioned. The Boise and Minidoka projects may be cited as other examples of a similar condition.

Seepage Losses in Various Classes of Material.—It has been the practice in the Reclamation Service for the past several years to have the project hydrographers make measurements of the seepage from canals in various materials to gain some idea of the actual and relative losses from canals in such materials. Precision of measurement is not aimed at, nor is it possible under the operating conditions. Rather, dependence must be placed on the multitude of measurements, thus making the error of a single measurement immaterial. In this way a fair knowledge of the actual and relative losses in different materials has been gained.

Table II has been prepared from these data. The materials are listed in the order of magnitude of losses in feet depth over the wetted perimeter per day. By no means all of the measurements made are included in this list, but only those that are known to be most reliable. Two hundred and seventy-seven measurements are listed covering 24 different classes of materials.

TABLE II—LOSSES PER DAY IN CANALS OF THE U. S. RECLAMATION SERVICE.

(Depths in feet per square foot of wetted area.)

Soil.	Number of observations.	Maximum	Minimum.	Mean
Gravel and sand	2	3.62	1.44	2.53
Gravel	38	7.05	.22	1.70
Gravel and rock meal	9	2.84	.88	1.56
Sand	5	1.79	.81	1.27
Rock meal	18	1.73	.38	1.24
Sand and loose rock	7	.86	.62	.72
Sandy loam	60	3.70	.01	1.01
Loam	5	1.44	.84	1.07
Sand and volcanic ash	21	1.66	.22	.90
Gravel and volcanic ash	5	1.54	.38	.88
Volcanic ash	3	1.16	.56	.82
Brule clay	4	1.11	.72	.91
Clay and gravel	18	1.34	.16	.79
Clay and sand	12	1.43	.50	.76
Adobe	9	.93	.46	.65
Hardpan and loose rock	2	1.1[illegible]	.21	.68
Clay and shale	7	1.02	.30	.59
Volcanic ash, clay and hardpan	4	.77	.46	.60
Cemented gravel and sandy loam	2	.47	.40	.44
Caliche	2	.49	.38	.43
Clay	12	.77	.11	.34
Clay loam	12	1.12	.06	.30
Gumbo and sandy loam	11	.77	.12	.29
Concrete lining	9	1.07	.06	.33
All soils	277	1.66	.43	.87

In the application of these data we encounter the same difficulty as in determining the correct value of Kutter's n to use for designing a particular canal. In fact, the difficulty is much greater. No two persons will describe a given material in the same terms. Hence it is very difficult to select the class of material and corresponding coefficient on which to base one's judgment as to the probable losses from the canal to be built. It is, however, necessary that a selection be made, and after having determined the average class of material through which a canal is to be built a selection can be made from the coefficient in Table II which appears to offer the best approximation to the case in hand.

Methods of Stopping Seepage.—Conveyance losses, in addition to the value of the lost water, frequently constitute a serious menace to adjacent lands and frequently to lands some distance away. In the latter case drainage ditches must be built which will probably remedy the situation, but in the former drainage is likely to prove ineffective. In that case the only remedy is to stop the seepage from the canal. The two most common methods of doing this are lining with concrete and puddling with silt. Concrete lining is very expensive, and on this account should be resorted to only after all other means have failed, especially if concrete materials are not readily available. Moreover, concrete lining does not have an indefinite life and is subject to injury from various causes, principally frost and alkali action, whereas earth puddle is permanent so far as its physical stability is concerned.

Each individual case must, of course, be considered in the light of all the local controlling factors, but the point it is desired to emphasize is that concrete lining is not the best remedy for all seepage ills. It has not even been demonstrated that it reduces the losses to a minimum. Table II gives three classes of material, namely, clay, clay loam, and gumbo and sandy loam, that show an average loss as low as or lower than concrete lining. The permanency of concrete lining depends much upon the foundation upon which it is laid. Where the foundation is suitable and the concrete of good quality, this form of lining has in many cases given excellent satisfaction. It is well, however, in all cases to consider fully the practicability of cheaper methods before doing much of this expensive work.

Typhoid in Large Cities of U. S. in 1920—According to the Journal of the American Medical Association for March 26, a survey of typhoid fever mortality in the 68 cities of the United States in 1920 having each more than 100,000 population and together more than one-fourth of the toal population of the country shows the following: Ten of the twelve cities with a population of over 500,000 had a rate under 5 in 1920, and only seven had such a rate in 1919; the average deaths per 100,000 in these 68 cities was 3.7 in 1920 and 4.2 in 1919; the striking drop in typhoid occurring between 1918 and 1919 which was ascribed to the typhoid immunization practiced in the army camps in 1917-1918 is borne out by additional data; there have been frequent small outbreaks of typhoid in 1920 attributable to drinking the contaminated water of rivers, small streams or springs in public parks or recreation grounds; typhoid is still decreasing in the large cities of this country at a rapid rate.

Garbage Reduction and Rubbish Incinerator Plants Recommended for Baltimore

The construction of a garbage reduction plant and rubbish incinerators, calling for a total expenditure of [illegible], is recommended for the permanent disposal of the city wastes of Baltimore, Md., by Mr. H. G. Perring, [illegible] Engineer, in a report submitted April 9 to the Mayor.

On May 1, 1919, the city entered into a contract with a company for the disposal of garbage by feeding to hogs. The contractor agreed to pay the city for each ton of garbage delivered a sum equal to 3½ times [illegible] per pound of live killing hogs on the Chicago market. On Jan. 15, 1921, the contractor removed his hogs and abandoned the contract.

Conclusions Regarding Garbage Disposal by Hog Feeding.—Regarding Baltimore's experiences with the hog feeding method of garbage disposal Mr. Perring's report has the following to say:

Hog feeding, the method in use in Baltimore up to a few months ago, has the following advantages:

(a) The feed values in the garbage are utilized.

(b) Seasonal fluctuations in amount of garbage can be compensated for by increasing or decreasing the size of the herd.

(c) A plant is already built on land owned by the city.

The disadvantages of hog feeding are:

(a) Incomplete consumption, involving the problem of disposal of the portions rejected by the hogs.

(b) Difficulty in delivering the garbage from so large a city in a fresh condition.

(c) Consequent malodorous conditions on the water gateway to the city.

(d) No large city has had satisfactory results with hog feeding of garbage.

(e) Because of the experimental failure of this method of disposal it is apt to become a nuisance.

Economics of Hog Feeding.—Baltimore should collect about 150 tons of garbage per day. One hundred hogs will consume one ton per day. The average number of hogs required would therefore be 15,000. The average gain in weight per hog should be about 1 lb. per day.

Assuming that the hogs are sold as soon as they have gained one hundred pounds in weight, the cost of producing 100 lb. of pork is about as follows:

Interest on cost of plant and equipment, about $15.00 per hog, 7% for 100 days	$0.29
Fixed charges per hog, includes immunization, dipping, transportation, medical care, etc.	5.00
Labor of feeding	1.50
Losses through death, 10% of herd (10 lb. of pork at 10 ct.	1.00
Cost of producing 100 lb. of pork	$ 7.79
Yield from 100 lb. pork at 10 ct.	$10.00
Cost of producing 100 lb. pork	7.79
Net returns on 100 lb. pork	$ 2.21
Net returns from one ton of garbage, assuming from the above that 50 lb. of garbage will produce one pound of pork	$ 2.21
Net returns per ton of garbage, assuming that it will take 50 lb. of garbage to produce one pound of pork	.88
During the year 1920 it cost the city 50 cents per ton to barge the garbage from the water-front to the piggery	$0.50
And $5.00 per ton to collect and haul it to the water-front	5.00
Cost of collecting and barging garbage to piggery	$5.50
Deduct returns from feeding, as above	.88
Net cost per ton for collection; delivery and disposal at a successfully operated piggery	$4.62

As success in operating a piggery depends on good management and prompt delivery of the garbage in a fresh state, it is doubtful whether as good results as above indicated would be obtained from hog feeding by city employes. Under the contract recently abandoned, which provided for the payment to the city for each ton of garbage delivered to the piggery, a sum equal to three and one-half times the price per pound of live hogs in Chicago, the theoretical cost to the city for collection and disposal was:

COST PER TON OF GARBAGE.

Collection	$5.00
Transportation by barges to place of feeding	.50
Interest on city's investment at the feeding plant	.07
Gross cost to city for each ton of garbage delivered at feeding plant	$5.57
Returns in accordance with the feeding contract on the assumption that pork is selling for 10 ct. per lb. in Chicago	.35
Net cost to city for collection and disposal	$5.22

These theoretical figures have not been realized and in fact the city has received no return but has been placed at considerable expense due to the failure of this method of disposal from various causes.

[illegible] relative to prospective returns from hog feeding are altered vitally by an assumption that the price of live pork will drop a cent or two a pound between the time the shoats are purchased for feeding and the time when the fattened hogs are put on the market. Some protection against this contingency can be secured by buying futures in mess pork on the Chicago Exchange, at the time the feeders are purchased.

While from a theoretical standpoint hog feeding has shown an advantage over other means of ultimate disposal, it can not be recommended for a city the size of Baltimore, from sanitary considerations. Hog feeding as successfully practiced by other cities calls for careful selection of the richer grades of garbage and the use of the remaining portion for fertilizing the farm operated with the piggery. When large quantities of garbage are produced and transported by scow, as is necessary here, such selection is not physically possible and any attempt at feeding without careful selection is foredoomed to failure.

The feeding of green garbage means the rejection by the hog of large quantities of material not suitable for foods which adds to the amount of material to be used as fertilizer or otherwise disposed of, possibly by incineration. The amount of rejected garbage would be so large in the case of a city the size of Baltimore that a much larger farm than is now used by the city would be necessary, as a large area would be required at all times on which to spread and immediately plow under. Any storing of garbage would result in nuisance in a few days.

Sterilizers have been built in which the garbage is subjected to heat, before feeding, to disinfect it. The State of Maryland Live Stock Commission has ruled that they will not permit the use of green garbage as a feeding material, yet many authorities claim the feeding of sterilized garbage to be impracticable as the hog is not able to make natural selection of the edible portions, but must take the cooked mass as it comes from the sterilizers.

Successful feeding requires the garbage to be delivered in a fresh condition, which means daily delivery of scows to the piggery. This is not impossible and in fact it is highly desirable that garbage be removed from the wharf each day and be not allowed to ferment on the scow—no matter what means of disposal are used

The feeding of garbage to hogs may be successfully handled in small cities where it is the continuation of the practice of the individual farmer.

The time of war when food products were at a premium, it was desirable to utilize what food value there was in garbage and the United States Food Administration urged this means of disposal. No such emergency now exists and hence with the recent unsatisfactory experience of Baltimore before us, we should no longer experiment in this field but go to a disposal method of proven worth.

Recommended System for Waste Disposal.—Mr. Perring's general recommendations for the permanent disposal of the city wastes are as follows:

(1) That householders be required to make careful separation of various wastes in three receptacles:

(a) Ashes.

(b) Rubbish.

(c) Garbage.

(2) That ashes be used:

(a) As fill in grading low-lying street beds at various points throughout the city.

(b) As fill behind suitable bulkheads in reclaiming lowland around the harbor.

(c) As fill in bringing to grade low-lying parcels of ground, old quarry holes, etc., preferably owned by the city.

(3) That collection of ashes be made twice each week in the outlying districts and more frequently in congested districts.

(4) No garbage or combustible wastes be allowed in the ash fills

(5) That collection of rubbish be made once each week.

(6) That four incinerators of two 15-ton units each be built in convenient sections of the city. All rubbish to be hauled to these incinerators, where salable material could be salvaged and the remainder burned without nuisance.

(7) The extension of rubbish incineration as the collections increase.

(8) That daily garbage collections be made from April to October, and three collections per week from October to April.

(9) That garbage be removed quickly to relay stations and thence to a central reduction plant by truck and trailer, trolley, railroad, scow or other means

(10) That a central reduction plant with a present maximum daily capacity of 300 tons be built:

(a) In or about the Curtis Bay section, near the fertilizer factories; or,

(b) Near the Back River Sewage Disposal Plant.

(11) That the reduction plant be designed so as to be added to at a minimum cost.

(12) That the city endeavor to collect every pound of garbage, and not under any circumstance permit private collections for hog feeding, fertilizing, etc.

(13 That the city own and operate its collection and disposal system just as it does its water and sewer systems.

(14) That no storage of garbage over one day be allowed at any point. That garbage as collected at relay stations be removed to the central loading point, where scows are used as a means of

transportation, the scows to be removed to the disposal plant each day even though but partly loaded.

(15) That careful investigation be made of the possible use of truck and trailer in garbage and waste connection and the whole collection system studied more carefully.

(16) That night soil be disposed of by dumping at Back River sewage disposal plant.

(17) That houses built in outlying sections of the city be required to be equipped with some form of individual incineration for garbage and rubbish.

(18) That dead animals to be disposed of be handled at the reduction plant.

COST OF RECOMMENDED SYSTEM.

Garbage reduction plant, 300 tons daily capacity	$1,000,000.00
Rubbish incineration plants, 120 tons daily	180,000.00
	$1,180,000.00

It is estimated that this cost will include all costs of sites, engineering, plant, buildings, etc. If the financing of the disposal of wastes is handled by a bond issue to be submitted to the people, the motorization of the collection system should be provided for and a total of $1,500,000 submitted. If further study does not show the desirability of motorization the remainder need not be issued.

Residual Aluminum Compounds in Water Filter Effluents

Although aluminum sulphate has been used as a coagulant in water filtration plants for many years, it is only recently that the appearance at times of alum compounds in filter effluents has been studied in connection with the hydrogen ion concentration in the natural alkaline waters. Previous conceptions of the appearance of alum in the effluent were based upon the passage through the filters of undecomposed alum. Theoretical considerations, supported by experimental results obtained in waterworks and elsewhere, appear to demonstrate fairly completely that the reaction of aluminum sulphate with the natural alkalinity of a water is a complex mobile transformation. The reaction seems to be delicately dependent upon the actual alkalinity of a water, its hydrogen ion concentration, rather than upon its potential alkalinity. The hydrogen ion concentration in turn is regulated to a large degree by carbon dioxide equilibria. Such are the conclusions reached by Abel Wolman, Maryland State Department of Health, Baltimore, Md., and Frank Hannan, Toronto Water Filtration Plant, Toronto, Canada, in an article by them which appeared in a recent issue of Chemical and Metallurgical Engineering from which the following data are obtained.

The simplest and most popular conception of the reaction of aluminum sulphate with the natural alkalinity of water is given by the following typical equation:

$$Al_2(SO_4)_3 + 3CaCO_3H_2CO_3 =$$
$$Al_2(OH)_6 + 3CaSO_4 + 6CO_2 \text{ or}$$
$$Al^{+++} + 3HCO_3^- = Al(OH)_3 + 3CO_2$$

This rigid transformation is usually accepted as approaching the average state of affairs when "normal" conditions obtain. The above equation has been responsible for the oft-repeated statement that "if sufficient raw water alkalinity is present, there is no excuse for the passage of aluminum compounds through filter beds." The simplicity of the reaction has been so frequently emphasized that the impression has been gained by the average filter plant operator that when the coagulum, $Al(OH)_3$, is not instantly and continually formed, the treatment is either careless or faulty. When inquiry, however, among many operators elicits the information that such difficulty as ineffective flock formation and residual alumina in filter effluents are by no means rare occurrences even with plenty of alkalinity, it seems wise to search for causes in other places than poor operation.

Such a search demands at once a reconsideration of alum reactions. Since the study of such reactions has been retarded in the waterworks field by the general hesitancy to question orthodox beliefs, it is necessary to pursue our inquiry into other channels. When this is done, two important series of data appear. These series are in conflict as to the nature of the compounds resulting from alum reactions, but are in complete agreement as to the absences of rigidity of state of any particular aluminum compound. In other words, we must pass from a viewpoint in which alum reactions result in stationary phenomena to one in which they appear as mobile, delicate equilibria. With such a new viewpoint, the formation of an insoluble coagulum as $Al(OH)_3$, when aluminum sulphate is added to water, becomes a desirability, but not necessarily an eventuality. Our problem now becomes to determine those factors which regulate the reaction in such manner that the desired result, an insoluble complete coagulum of $Al(OH)_3$, is obtainable.

Recent Interpretations Based on Hydrogen Ion Concentration.—The important characteristic of recent conceptions of $Al_2(SO_4)_3$ reactions is to be found in the realization that the formation of $Al(OH)_3$ is a reversible progressive reaction, dependent upon a number of conditions, the most important of which is probably the hydrogen ion concentration or pH value of the solution in which one is working. The nature of the solutions obtained, however, when aluminum hydroxide is dissolved in the presence of acids or bases has been the subject of much discussion. The underlying hypotheses of these discussions may be divided into two classes. In the first case, the solution of $Al(OH)_3$ is ascribed to processes of peptization or change in physical structure of $Al(OH)_3$, but not to change in chemical composition. The second school of thought bases its understanding of the processes entirely upon the hypothesis that the changes taking place when $Al(OH)_3$ is formed and redissolved are due to variations in chemical combination. The contrasting viewpoints emphasize changes in physical state as against changes in chemical combination. The salient features of each conception are outlined below, in order to demonstrate that, whatever viewpoint is accepted, one must reach the conclusion that the complete formation of the insoluble $Al(OH)_3$ in water is by no means as frequent an accomplishment as has been tacitly assumed.

Changes in Physical State.—The evidence supporting the hypothesis that $Al(OH)_3$ may be redissolved in solutions through the increase of hydroxyl ions, because of a process of peptization or subdivision of particles, is by no means complete. Mahin, Ingraham, and Stewart,[1] for example, conclude that aluminum hydroxide should not be considered as amphoteric since they claim to have established by the measurements of the heat of solution of aluminum hydroxide in sodium hydroxide, of the quantitative relations between ammonium nitrate and sodium aluminate and observations made upon the electrolysis of sodium aluminate that the colloidal properties of aluminum hydroxide play a far more important part in conditioning its solubility in bases and acids than the possible formation of aluminates.

The above statements give a fair representation, it is believed, of the hypotheses presented by the adherents of the "peptization" theory. It is important to emphasize that these authors and others have demonstrated the ephemeral character of the insoluble $Al(OH)_3$. They support simply one explanation of the cause of the solution and precipitation of the hydroxide—namely, that due to change in physical structure because of some effect of hydroxyl ions. They disagree with the second class of workers, not on the fundamental idea of the instability of the insoluble $Al(OH)_3$, but only on an explanation of the cause of this instability.

Changes in Chemical Constitution.—The basis of the explanation of the change of state of $Al(OH)_3$ as due to a change in chemical constitution may best be indicated by the following quotation from Stieglitz.[2]

"Aluminum hydroxide dissolves in acids. From its solution in hydrochloric acid, an aluminum salt, aluminum chloride, $AlCl_3 6H_2O$, is obtained. It also combines with strong bases, dissolving, for instance, in a solution of sodium hydroxide and forming an aluminate, $NaAlO_2$ . . . According to the best knowledge we have on the subject, the molecule of aluminum hydroxide has the following structure or arrangement of its atoms $Al(\text{-O-H})_3$. It is readily seen that the cleavage of the molecules may produce either aluminum and hydroxide ions, characteristic ions of a base, or aluminate and hydrogen ions, characteristic ions of an acid:

$$Al^{+++} + 3OH^- = Al(\text{-O-H})_3 =$$
$$AlO_2^- + H^+ + H_2O."$$

Loeb[3] further adds that "it is obvious that between the action of acids and of bases producing these two types of electrolytic dissociation there must be one hydrogen ion concentration in which aluminum hydroxide is practically neither able to form Al^{+++} nor AlO_2— ions, and this would be the isoelectric point. The significance of this statement will appear later in the discussion.

The question naturally arises now as to what conditions determine the formation of the insoluble hydroxide and the soluble complex salts of aluminum. In the answer to this question should appear the clue to the cause of the puzzling features of present-day coagulation problems in water supplies. Fortunately an abundance of [illegible] data are available in different fields. They are of sufficient interest and [illegible] to be discussed at length in this paper. Their practical importance in indicating a solution of our specific problems will be outlined in a later section of this discussion.

In March, 1913, at the Milwaukee meeting of the American Chemical Society Hildebrand[4] presented a paper on "Some Applications of the Hydrogen Electrode in Analysis, Research and Teaching." In this paper Hildebrand demonstrated definitely that aluminum hydroxide is precipitated by sodium hydroxide, while the solution of aluminum sulphate is still strongly acid, the hydrogen ion concentration during the precipitation varying roughly between 10^{-3} and 10^{-5}. He also shows that aluminum hydroxide goes into solution with an excess of alkali, in which the proportion of alkali used corresponds to the formation of $NaAlO_2 — nH_2O$. It is interesting to recall that Hildebrand supported the theory of the solution of aluminum hydroxide as an acid rather than as a colloid, as claimed by Mahin, Ingraham and Stewart.[3] Hildebrand bases his refutation of the above authors' contention upon the fact that the ultramicrosope fails to show the presence of a colloid in the solutions studied, although the ordinary solutions of aluminum hydroxide produced by dialysis show submicrons very plainly in the ultramicroscope. The conclusions reached by Hildebrand were later substantiated by Bancroft[5], Blum[6], and others.

The work of Blum is most significant in attempting to clarify some of the results frequently obtained in the application of aluminum sulphate to water. This author has made extensive studies of the reactions of the aluminum compounds with certain bases. His studies are interesting and valuable.

The results of Blum's experiments appear to indicate the existence of definite aluminates of the formulas $NaAlO_2$ and $KAlO_2$ (or multiples thereof) in solutions obtained by the action of alkalis upon aluminum hydroxide. More importantly for the particular subject with which we are now concerned, the experiments demonstrate beautifully that the amount of $Al(OH)_3$ held in a given alkaline solution is a function of the alkalinity of the solution. This conclusion cannot be too greatly stressed, since it appears to the writers of this paper to be the basis of a new and better understanding of the whole mechanism of alum coagulation.

The obvious resultant of the above tests is stated in brief by Blum.

"In the case of amphoteric hydroxides, such as $Al(OH)_3$, it is obvious that an excess of the base is to be avoided and it therefore becomes desirable to select that degree of alkalinity which will insure most nearly complete precipitation and at the same time avoid resolution of the precipitate."

Data adapted from one of Blum's publications which show quantitatively that the precipitation of aluminum hydroxide by ammonium hydroxide is complete when the pH of the solution is between 6.5 and 7.5. What is this point of optimum precipitation in our different water supplies? Have we ever paid any attention to it? We must expect certainly that there are numerous points in coagulation in which re-solution of $Al(OH)_3$ is always in operation. The occurrence of aluminum compounds in filter effluents should be as common as it is now considered rare. Chance, and not mischance, in the past seems to account for its failure to appear.

Further important experimental work on the reactions and constitution of aluminum compounds may be found in the studies by Heyrovsky[7] on the electroaffinity of aluminum, by Michaelis,[8] and on the production and chemistry of satin whites by Cobenzl.[9] The latter adduces reasons for his belief that the reaction of $Al_2(SO_4)_3$ with $Ca(OH)_2$ is as follows:

$$Al_2(SO_4)_3 + 4Ca(OH)_2 = Al_2CaO_4 + 3CaSO_4 + 4H_2O$$

instead of that commonly accepted

$$Al_2(SO_4)_3 + 6CaO = Al_2O_3 + 3CaSO_4 + 3CaO$$

It is interesting to note that Cobenzl suggests that calcium aluminate, when formed, is in a colloidal state, and the particle size may be regulated by the degree of alkalinity of the solution. May, we not find it necessary to search for such complex configurations in our water supply reactions before scientific control is possible?

Significance of Present Discussion in Reference to Problem of Alum Coagulation in Water Supplies.—A survey of the facts and theories collected in the preceding portions of this paper has led the writers to formulate a hypothesis regarding the action of aluminum sulphate in water supplies. The important features of this hypothesis are as follows:

Aluminum compounds may exist in three states, defined by their hydrogen ion concentration—namely, (a) as non-ionogenic or isoelectric $Al(OH)_3$, (b) metal aluminate (e.g., Na or Ca aluminate) and (c) alumino-acid salts (e.g., aluminum chloride, aluminum sulphate, etc.). Thus, in practically every water treated with alum, at any point other than the isoelectric point (which has not yet been determined for varying waters), an equilibrium may exist between hydrogen ions, metal aluminates and non-ionogenic or isoelectric Al(OH) (If the pH were lower than the isoelectric the Al ion would replace the aluminate. In water practice, however, such cases would be rare.) It is reasonable to suppose that just as often as not the pH of a water is not correct to permit the complete formation of only $Al(OH)_3$. For this reason the occurrence of other aluminum compounds should not surprise one in filter effluents, for such compounds are soluble and need not be removed by the sand.

Some waterworks investigators have recognized the possibility of formation of aluminum compounds other than the insoluble hydroxide. In most instances, however, these possibilities have been ascribed both to insufficient alkalinity and to peptization. In this manner advantage has been taken of both the theories of peptization and of chemical combination. It appears from the preceding material that the latter explanation alone may suffice if we do not neglect the important factor of the hydrogen ion concentration of the medium with which we are at work. At this point also it is important to suggest that not only low alkalinity may be fraught with danger but too high hydroxyl ion concentration may not be so desirable for proper and successful coagulation and for the complete elimination of soluble aluminum compounds. It seems, as a preliminary theory, that as one departs from the point or area of favorable hydrogen ion concentration in coagulation processes, one passes, in either alkaline or acid direction, into fields of re-solution of aluminum hydroxide. This conception, it is clear, is independent of the causes of such re-soluton. It is important, therefore, to keep in mind the ever-present possibility of missing the favorable threshold area of coagulation and passing into the unfavorable dissolution areas. This interpretation of the action of aluminum sulphate is widely different from that hitherto accepted, in which the presence of delimited areas of effective flock formation was but little emphasized.

Does the literature of water purification disclose any data in confirmation of the above hypothesis of equilibrium conditions of alum reactions? It should be difficult to obtain such material, since it is only recently that determinations of hydrogen ion concentration have been made in water. Hitherto only potential alkalinity and acidity have been determined, because of current methods of filtration, while actual alkalinity or pH values have remained unknown. It is these latter conditions which are usually operative in conditioning our water supply reactions

TABLE I (ADAPTED FROM MORISON)

Volumetric Estimation of Alum in Solution in Waters Treated With Various Doses of Aluminum Sulphate.

Description of sample	Approx. parts per million aluminum salts in supernatant water.
Raw water + 25 p.p.m. alum..	1.4[illegible]
1 liter evaporated for experiment	
Raw water + 10 p.p.m. as above	1.47
Raw water + 23.4 p.p.m. as above	0.60
Raw water + 15.0 p.p.m. as above	0.90
Raw water + 40.0 p.p.m. as above	1.75
Raw water + 25 p.p.m. as above.........	1.47

Also optimum clarification dose

Zones of Coagulation.—Fortunately we have available an excellent series of experiments in water which does much to substantiate at least some of the possibilities of the suggestions outlined above. It is interesting to find that the author of these experiments, in the distant land of India, did not completely recognize the significance of the data which he reports. In April, 1916, Captain J. Morison[10] of the Indian Medical Service reported upon a series of studies of the clarification of the water supply of Poona by means of alum. The results he obtained may be well interpreted in the light of the theoretical considerations previously presented. Morison's first experiments were made by adding increasing quantities of aluminum sulphate to the turbid water to be studied. He found that the clarification of the water with these different doses exhibited the familiar "zone phenomenon"—that is, "by increasing the dose of alum up to a certain point the clarification improves up to an optimum point where the settlement is excellent; any alum in excess of the optimum point again results in incomplete settlement. Increasing the doses of alum now gives less and less settlement, until a point is reached where the settlement is no better than that of the untreated water. Further increments of alum produce settlement which finally becomes complete. The improvement, however, is not uniformly continuous. It is broken by waves of which as many as three have been noted."

Morison, in addition, makes the important notation that "using now pure hæmatoxylin (Grübler) in a 1 in 1,000 watery solution . . . it was found that a red color was given by the natural water and by the water completely clarified by a dose of alum just sufficient to clear it. If this dose were not attained the water was turbid and gave a lavender or purple color with hæmatoxylin. If the dose were exceeded the clear solution gave either a reddish color which was rapidly decolorized, or a permanent bluish lavender; the latter color appearing when the dose of alum approximated or exceeded 2.2 times the alkalinity. This seemed a curious result. The hæmatoxylin, used to detect the presence of alum, showed that the alum was completely precipitated at a point corresponding to half the weight of alum necessary to react completely with the alkalinity of the water, and that both below and above this point, in spite of there being in each case an excess of available alkali, there still remained some alum in solution."

Morison then concludes: "In the above experiments where the aluminum sulphate was present in quantities in which it ought to have been completely precipitated by the alkalinity of the water, certain of the aluminum hydrate remained in the supernatant fluid except when the optimum dose of alum was used." With this conclusion in mind, Morison then determined quantitatively the amount of alum present in such supernatant liquors and found that alum could always be detected when the doses were below the optimum point. At the optimum dose the alum, if present at all, was in minute quantities. Morison's figures are given in Table I. It is interesting to recall also that Morison found residual alum present in slow sand filter effluents in Poona, where alum-treated waters were being applied to slow sand beds. The results were not surprising. The converse of this has been observed by one of us, when on one occasion the alum application was eliminated completely from a mechanical filter for five consecutive days. The effluent nevertheless continued to give the alumina reaction with little or no reduction during the whole of this time.

Of even greater significance in connection with the present subject is the fact that Morison demonstrated that the hæmatoxylin test reacted with hard waters (356 p.p.m.) in a manner very similar to that described for the soft waters (25 to 50 p.p.m.). "Below the zone of settlement, hæmatoxylin gave a gradation of shades of lavender; at the optimum point a red color was produced; immediately above this point the hæmatoxylin was decolorized and, when the dose exceeded 610 p.p.m. (alum) the lavender color returned.

Importance of pH.—A close study of Morison's curves and figures leads one at once to the conclusion that the phenomena he noted were entirely due to changes in hydrogen ion concentration, similar to those outlined in the earlier portions of this paper. The similarity between Morison's curves and those recently presented by Smith[17] is so striking as to lend further emphasis to the controlling importance of pH in determining coagulation phenomena.

In the waterworks field Morison[10] has supplied sufficient evidence of the probable existence of a point or zone of most effective coagulation. In the case of the water with which he was working this point coincided with the point of most satisfactory sedimentation. This coincidence, we believe, was largely a matter of chance, for it is our feeling that the zone of complete coagulation is determined by pH conditions, while that of sedimentation will probably be dependent upon many other factors. Much work remains to be done before any real conclusions upon any portion of this interesting subject are to appear.

If the assumptions given above are in any way warranted, we should be able to test their accuracy in the following manner: Theoretically the isoelectric point for $Al(OH)_3$ should be in the neighborhood of pH 7.0. If we are experimenting, therefore, with a water having a pH value of 8.0 to 8.6, we should be able to obtain better precipitation of $Al(OH)_3$ if we acidify such a water to bring it to a value nearer pH 7.0. The heroic treatment of acidifying a water to improve coagulation is, of course, contrary to most canons of water purification.

Conclusions.—Theoretical considerations, supported by experimental results obtained in water work and elsewhere, appear to demonstrate fairly completely that the reaction of aluminum sulphate with the natural alkalinity of a water is a complex mobile transformation. The reaction seems to be delicately dependent upon the actual alkalinity of a water, its hydrogen ion concentration, rather than upon its potential alkalinity. The hydrogen ion concentration in turn is regulated to a large degree by carbon dioxide equilibria. Evidence so far accumulated seems to indicate that complete precipitation of $Al(OH)_3$ takes place at a hydrogen ion concentration somewhere near the neutral point, pH 7.0, unless disturbing or buffer influences are operative. Outside of this zone of favorable alkalinity re-solution of insoluble flock occurs to a greater or less degree.

It seems clear, from the above considerations, that the appearance of aluminum compounds in filter effluents should not be accepted as due to faulty operation, according to orthodox interpretations, but to failures due to misunderstanding of the reactions involved. This statement is given in the nature of a hypothesis, to be substantiated by further experimental evidence. If the hypothesis is found to be true, the problem of residual alumina, not only in filter effluents, but in all coagulated waters, may be attacked from a new angle.

The writers have studiously avoided any reference to the sanitary, physiological or economic importance of the passage of soluble aluminum compounds through filters. That it has a great practical importance, however, the little data we now have apparently confirm. Owing to the controversial nature of the subject, it appears best to reserve discussion of this phase until more accurate and complete evidence is available.

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Report on Equipment and Operation of Chicago's Municipal Reduction Plant

[illegible] of the present year [illegible] Council [illegible] Committee on Efficiency [illegible] Rehabilitation and a sub-Committee on W[illegible] employed [illegible] J. S. Osborn, of Cleveland, O., [illegible] means of increasing efficiency and economy at the city's refuse reduction plant. Acting in part upon Major Osborn's recommendations, the sub-committee reported an estimate for the purchase of new equipment and alterations of old, totalling $134,000, or more than 25 per cent less than the department's estimate of $180,000. The sub-committee also reduced the department's estimate for repairs from $41,000 [illegible]

The following tabulation shows the total cuts made by the sub-committee from the departmental estimate:

	Dept. est.	Sub-com. est.	Reduction.
Reconstruction and extensions	[illegible]	[illegible]	$16,000
Repairs by contract or open order	[illegible]	20,[illegible]	20,300
[illegible]	[illegible]	[illegible]440	5,820
[illegible]	[illegible]	[illegible]	12,100
[illegible] engineer	[illegible]	[illegible]	11,880
[illegible] mechanics	[illegible]	1[illegible],300	6,600
[illegible]	[illegible]	[illegible]	3,100
Garbage handlers	248,000	210,000	38,000
Total reduction on above items recommended by sub-committee			11[illegible],100

The sub-committee also recommends, in line with Major Osborn's report, that the method of disposing of by-products be handled on a competitive basis and that contracts for the sale of by-products be awarded on the basis of those competitive bids so far as possible. This will in all probability secure greater returns to the city for the sale of by-products. More genuine effort should be made to obtain a larger number of bidders. A surety should be required on all contracts to protect the city from losses on falling markets or on noncompletion of contracts.

Following is an abridgement of Major Osborn's report:

Scope and Objects of Report.—Investigations and studies of the plant were made with the view of determining its adaptability for the purpose intended, and the alternatives of undertaking additional construction, the installing of new equipment and making repairs, were singly and collectively considered. Payrolls, operating cost of existing equipment, and expenditures for repairs and maintenance were studied to discover possible economies in operation. The records and methods of disposing of by-products were also investigated in order to determine whether improvements could be made and the revenues increased. In arriving at conclusions, due consideration was given to existing plant facilities as well as to the results obtained and obtainable.

Historical.—Prior to 1905, Chicago had no systematic method of garbage disposal. In 1905 a contract was awarded to the Chicago Reduction Co. for disposal of garbage at plant located at 39th and Iron Sts. in the stock yard district, whereby the contractor disposed of all garbage delivered directly to the plant by wagons or by barges from loading stations, located on the Chicago river. Under the contract with the Chicago Reduction Co., the city paid them $47,500 annually for this work.

The contract with the Chicago Reduction Co. expired in September, 1913, and from the time of expiration until the plant of the Chicago Reduction Co. was purchased by the city and again placed in operation in 1915, the garbage was temporarily disposed of by dumping.

The old plant of the Chicago Reduction Co. was purchased for approximately $275,000 and consisted of land, receiving building, primary dryers, secondary dryers, extractors, finishing dryer and mill house, and power plant. The plant, as reconstructed, together with the equipment in use, have not proven adequate, and many features specially designed have been found unsatisfactory. At the present time, the larger part of disposal work is being done in the old plant with the same equipment as originally purchased from the Chicago Reduction Co.

The expenditures made for purchase of land and for rehabilitation, and new construction of this plant, according to comptroller's records to Dec. 31, 1919, amounted to [illegible]

Receiving Building.—The garbage is delivered now, as in former years, to the plant either directly by wagons or by barges from two loading stations situated respectively at Oakley and Chicago Aves. on the Chicago river. The direct delivery by wagon is made during the day and practically all wagons arrive at the plant between 10 a. m. and 3:30 p. m. The garbage from the two loading stations on the Chicago river is delivered by transporting the wagon bodies by barges to the disposal plant. The barges usually arrive between 6 to 7 p. m., are unloaded at night and returned for the next day's collection.

Formerly, the Chicago Reduction Co. used a stiff-leg derrick by which garbage was dumped into piles from the wagon boxes, whence it was discharged by an elevator onto conveyors running through the receiving building.

At present, the wagon bodies are taken from the wagons or from the barges into the receiving building by means of electric monorail cranes, and the garbage dumped into large concrete receiving pit. The monorail system and concrete receiving pit were installed by the city after the purchase of the plant.

The times of delivery of garbage and the necessity for unloading promptly requires the operation of the cranes night and day. The night crew works from 6 p. m. to 2 a. m., with most of the unloading completed by midnight or by 1 a. m.

The garbage, after being discharged into the present concrete receiving pit, is shoveled through hopper gates onto three steel conveyor belts, which extend under the storage pits and through the old receiving building. It is then discharged through spouts to three conveyors which carry the garbage to the top of the primary dryer building. The middle conveyor belt in the receiving building discharges through a crusher which was originally installed by the Chicago Reduction Co., and from the crusher to one of the conveyors leading to primary dryer house. The other two conveyors were provided with crushers at time of reconstruction, but they did not prove satisfactory and were abandoned. The reason for crushing or shredding the material is to facilitate the work of drying, and after drying it is also easier to extract the grease by percolation. The budget of 1921 carries estimates for installation of two additional crushers of the same type as now in use. While the garbage is being conveyed through the receiving building, some of the rubbish is picked out (but only a small amount), consisting of the large articles such as banana stems, wood and large tin cans which would cause trouble in operation of equipment.

Primary Dryers.—The garbage, delivered over the top of the primary dryers, is fed by hand through spouts to the front end of the dryers. The primary dryers consist of six direct-heat dryers provided with a brick combustion furnace at the front and a dust chamber at the rear. The heat for drying is supplied by fuel-oil burners in the combustion furnace. The dryers are pitched towards the rear and provided with lifting angles on the inside of the shell so that as they revolve the garbage is carried towards the rear. The combustion gases from the furnaces pass through the dryer, mingling with the garbage and evaporating the moisture. At the rear end of the dryer, the partially dried garbage is discharged onto a conveyor and the combustion gases carrying the moisture pass to the dust chamber from which they are exhausted by fans and discharged into the condensing tower. In the condensing tower the gases are passed through water sprays and then discharged through one of two stacks.

The six primary direct-heat dryers were installed by the Chicago Reduction Co. approximately 13 years ago. They have been in service longer than is usually considered the life of dryers when subjected to such severe usage, with the result that it has been necessary to continually make extensive and costly repairs in order to keep these dryers operating. Since the primary dryers are practically the heart of the plant, it would be necessary to close down if they were out of service. Due to the worn condition of the present dryers, they should be replaced. The installation of new dryers will eliminate not only the excessive cost of maintenance, but also eliminate the escape of gases and vapor into the drying room, as well as the labor required in cleaning up the material which now leaks through the present dryers.

The budget for 1921 contains an estimate for replacing the six primary dryers. When new dryers are installed, the brick combustion chamber should be redesigned to eliminate the trouble experienced in the warping and burning out of the dryer shell by the intense heat developed by the oil burners, the flames of which impinge against the shell. It would be difficult to maintain even new dryers under the conditions as they exist at the present.

In the operation of the primary dryers, the material is subjected to very intense temperature and occasionally the material will be found burning as it is discharged. Evidently the high temperature carbonizes some of the grease in the garbage, thus reducing the quantity as well as the quality of the grease. It would be desirable to determine by tests and analysis the results that are now being obtained in the primary dryers in order to improve, so far as possible, the quantity and quality of by-products.

Secondary Dryers.—The material, which is partially dried in the primary dryers, is carried away by means of conveyor and elevator and discharged through spouts into one of two secondary dryers, located in what is known as No. 2 dryer house. The secondary dryers are of the Cummer type, and were a part of the original Chicago Reduction Co. equipment. They differ from the primary dryer by being encased in a brick setting so that the combustion gases from fuel oil burners circulate around and through inlets into the dryer.

The process of drying is a continuous operation. The material is inserted at the front end of the dryer and delivered at the rear, while the gases are exhausted at the charging end. The two dryers have been used for a number of years, and at time of Major Osborn's inspection, only one was in service, the other being in need of repairs to the shell and also of alignment so as to prevent the breaking of the driving mechanism. The passing of the garbage through the secondary dryers completes the drying and it is then ready for percolation or extraction of grease.

Extraction.—The dried garbage from the secondary dryers is carried by conveyors and elevators to the top floor of the extractor building, and then charged into extractors for recovery of grease by means of a solvent (gasoline).

The extractors in use consist of seven vertical tanks which were originally installed by the Chicago Reduction Co., except two, which were replaced during 1920. The dried material is placed in the extractor tanks and washed with gasoline. The grease unites with the solvent and the solution is then drawn off at the bottom and pumped to stills, where the solvent is vaporized, then condensed and returned to storage for future use. The grease remaining in the stills is pumped to treating tanks, thence to storage ready for sale or shipment. The material left in the extractor tank after the grease is recovered is still saturated with the solvent which is then vaporized by application of steam and recovered by condensers. After extraction, the side outlet doors on the extractor tanks are opened and the material, from which the grease has been taken, is raked out onto a conveyor.

The seven extractor tanks now in service, with exception of two new ones, are badly worn and in some cases not serviceable. The budget for 1921 contains an estimate for replacing four of the extractor tanks, which it will be necessary to do if this part of the plant is kept in a safe and serviceable condition. The replacement of the worn vertical extractors will provide capacity additional to that of the revolving extractors in the new plant. The additional capacity thus secured will be advantageous at times of maximum production, or in reducing the time the plant would necessarily have to be kept in operation each day.

Adjoining the old extractor plant, a new extractor plant was constructed by the city approximately three years ago, and equipped with three revolving extractors, as manufactured by the Kutztown Foundry & Machine Co., of Philadelphia; together with the necessary solvent tanks, stills, pumps and piping. The new extractors have never been used except for trial runs of a few charges because they were equipped with special hydraulically operated rack and pinion drives, which were not serviceable. The budget for 1921 includes an estimate to care for installation of new drives so that the new extractors can be placed in service.

The still, installed in the new extractor plant, are now used for recovery of grease extracted in the old plant, and it is desirable that the installation of new drives, provided for in the budget, be made and the whole plant be placed in operation. In the operation of the new revolving extractors, some minor changes will be found necessary, such as the elimination of the hopper underneath, since it will be found difficult to discharge the percolated tankage through the existing hopper gates onto conveyors. When placed in operation, the three new revolving percolators will have capacity to handle most of the tankage to be degreased.

Finishing Dryers and Screens.—The material discharged from extractors contains considerable moisture added by use of steam in driving off the solvent. Therefore, it is necessary that it be dried before going to mill house. The extractors are discharged into conveyors which, in turn, discharge into elevators, delivering the material to top of dryer house No. 4, where it is passed through rag screens, wherein the rags, bones and rubbish are screened out and the material passing through the screen discharged into hopper underneath. The screenings are discharged onto a picking belt, from which the rags and bones are picked off and the rubbish carried by the belt to storage pile at side of building, after which it is disposed of under contract by dumping while the recovered rags and bones are sold. This material is next conveyed from the hoppers to the feed end of either one of the two Atlas dryers in No. 4 dryer house, which are used as finishing dryers. After drying, it is conveyed to the mill house and passed over a magnetic separator which removes metals before it goes to the disintegrators.

Mill House.—The tankage from finishing dryers is elevated in the mill house and screened. The material, which does not pass through the screen, is discharged into cage mills where it is disintegrated and again elevated and passed through screens. The fine material, which passes through the screens, is conveyed to storage hoppers where it is ready for shipment. The finishing dryers and mill house were constructed by the city in rebuilding the plant. The equipment in the mill house, and the two Atlas dryers used for finishing, are the only new additions to the plant which are used with exception of the stills in the new extractor building.

Power House.—A new boiler plant has been constructed containing four 500 HP. water tube boilers, equipped with Riley underfeed stokers, coal and ash conveyors and a coal bunker. This installation, with the exception of piping, was completed approximately two years ago. The budget for 1921 includes an estimate for completing the piping. The operation of the new boiler plant will permit considerable saving in labor now required for firing, handling of coal and ashes in the old boiler plant. At the same time, steam can be delivered in better condition, for operating the extractor plant, thus effecting a greater economy in coal consumption.

General Summary of Equipment.—From the above description of the plant as now operating, it is evident that most of the work is accomplished with use of equipment installed by the Chicago Reduction Co. The following summary gives the changes made in reconstruction of plant by the city and present status of the installation:

1. An unloading system using monorail and electric hoists, which unloads the garbage into concrete storage pit. It was installed by city of Chicago and is now in operation.
2. A garbage press for pressing green garbage before drying in primary dryers, which was designed and installed by city. It was found that the garbage would not feed through pressing roll and this press was abandoned.
3. Number 3 dryer house, containing two 7-ft. diameter by 60-ft. long Atlas dryers were installed by city and operated by city for about one year, when the first ring of dryer shell was replaced, due to wear. Trouble was experienced in driving mechanism and in keeping dryers on the trunnions. The dryers have been out of service for approximately two years.
4. A complete new extractor plant with revolving extractors was installed. It will be placed in service when the rack and hydraulically operated pinion drives are replaced. The stills and pumps are now used in conjunction with old extractor plant.
5. Dryer Houses Nos. 4 and 5, containing four Atlas dryers, where installed by the city. Two dryers in No. 4 dryer house are now used for finishing dryers. The rag screens, installed in this building by the city, are now used.
6. The mill house, for disintegrating and screening tankage, was installed by the city and is now operating.
7. A power house, containing four 500 HP. Page-Burton

water tube boilers, equipped with [illegible] stokers was installed by the city and complete [illegible] piping.

8. Shops, store room, chemical laboratory and office were constructed by the city and are now in service.

9. Conveyors were installed by the city for new parts of plant now operating so far as plant operates, and also additional conveyors, which were installed to connect up parts of old plant with the new.

10. The Atlas dryers in No. 3, 4, and 5 dryer houses were all originally equipped with chain grate stokers for use of coal, but with exception of two dryers in No. 5 dryer house, the stokers have been removed and fuel oil burners installed. The reason given for the change is that stokers in burning coal required large amount of labor in handling coal and cleaning out ash from dryer settings where dryers were entirely bricked in with a combustion chamber extending the full 60 ft. length. Furthermore, it was claimed that it was difficult to use them since when dryers were not in continuous service of 24 hours per day, furnaces could not be quickly heated up to temperature for starting or cooled off at time of closing down. At time of inspection, none of the Atlas dryers were in operation and the merit of contention could not be determined.

Quantity of Garbage Reduced and By-Products Produced.——The quanity of garbage reduced since the plant has been operated by the city has decreased each year as shown by the following table:

TONS OF GARBAGE REDUCED ANNUALLY, 1915 to 1920.

Year.	Tons.
1915	152,892
1916	134,292
1917	100,146
1918	84,974
1919	82,820
1920	80,132

The quantity of garbage to be reduced, based on population, is proportionately much less than that produced in other cities of the United States. The quantity reduced in Chicago in 1920 was approximately 60 lb. per capita as compared with 107 lb. in Cleveland. The per capita production in the majority of the larger cities will range between 150 and 200 lb. per capita per year. The reasons for the small amount, as compared with other cities, is difficult to determine, but is probably due to several causes such as:

(1) Non-collections in sections of the city which are not built-up.

(2) Garbage collected by individuals or private rendering companies.

(3) The mixing of garbage with ashes and rubbish, which is collected and disposed of by dumping. This method is followed in some sections of the city.

(4) The use of incinerators in apartment houses.

(5) A reduction in the volume of garbage, resulting from the conservation of food.

What influence any one of the foregoing causes has on the quantity of garbage has not been determined, but the falling off in quantity, even with an increase in population, is contrary to the result found in other cities.

The seasonal or monthly variation, however, compares favorably with that found in other cities, as it is usually found that the quantities during the summer months of maximum production are approximately twice that produced during the winter months.

During the period since the war, there has been a great increase in the value of by-products that can be produced from garbage, resulting in more effort being made by private companies or individuals to collect garbage. However, with the present decline in values, most cities are experiencing an increase in quantity of garbage collected, probably due to failure of private companies to continue collection. This is evident, to some extent, in the collections made in Chicago. During the past year, the total tonnage collected was less than any previous year the plant had been operated by the city, but during the last four months of the year the amount collected per month was greater than for the corresponding months of 1918 and 1919. During this time the market for by-products declined very rapidly. This would indicate that the tonnage for 1921 will increase considerably over that of 1920.

The results obtained in recovery of grease would indicate that garbage in Chicago is not as rich in grease as found in other cities. The quantity recovered in Chicago being on an average of approximately 40 lb. per ton where plants in other cities recover greatly in excess of this amount, usually averaging approximately 60 lb. or more per ton where full recovery is made. It is questionable whether all the grease is recovered or a part is not destroyed during the process of reduction. It would not be difficult to determine by analyzing the garbage as received, and during the different steps of the process, whether the best results obtainable were being secured.

The quantity of tankage produced at Chicago is from 17 per cent to 18 per cent of the weight of the garbage reduced, and is greater than in a majority of other cities. This is due to the fact that in the dryer process all solids are recovered, whereas in the majority of other plants using the digester method a considerable part of the solids are lost in solution and are drained away with the sewage.

Sale of By-Products. In the sale of by-products, such as are produced in a municipal reduction plant, effort should be made to secure responsible bidders, and as much competition as possible. It is evident from an investigation of the records of the plant that in the past the fullest effort to attain these results has not been made. The reason given is that sales have been made on the basis of the run of by-products as produced without guarantee on the part of the city as to quality, and that bidders do not bid as readily under these conditions. It is customary, however, to make guarantees in selling by-products. The grease is usually sold on the basis of a guaranteed per cent of saponification and free fatty acids. In case the product on analysis does not meet such specifications that pro rata reductions in price are made in proportion to the amount of excess unsaponifiable matter.

The tankage has also been sold at a flat price per ton. This is not the trade practice. It is customary to sell tankage on the basis of a unit price bid for the fertilizing elements such as ammonia, bone phosphate of lime, and potash.

Where sales are made without guarantee, it is only natural for the buyer to bid conservatively, resulting in loss to the city. It is desirable to guarantee the quality as an incentive to those in charge to produce a grade of grease and tankage which will meet the specified requirements, since when no guarantees are made there is a tendency to produce a grade inferior to that which might be attained.

It is not difficult to sell by-products if bidders are assured of their quality, and the policy of strict observance of the terms of contract is adopted.

The experience of other cities operating municipal reduction plants demonstrates the fact that the prices obtained for their by-products compare favorably to prices received by private companies operating plants producing the same quality of products. To sell by-products, such as grease and tankage advantageously, requires attention on the part of those handling the sales and the work must be conducted on the same basis as if done by a private company. Buyers will be secured without trouble when satisfactory methods are practiced.

The tankage produced at the Chicago reduction plant is considered by buyers as equal in quality and mechanical condition to the garbage tankage produced by private reduction plants, and will sell at the same price. The grease produced at Chicago is considered inferior to that produced by other plants, due to the larger amount of unsaponifiable or total impurities contained. The average for 25 samples of grease analyzed during 1920 show a total impurity of 7.65 per cent, and 5.86 per cent was unsaponifiable. However, this should not influence the comparative price to a great extent, probably not in excess of 3 per cent.

A record of sales of grease during the past three years shows the following:

During 1918 the grease was sold to Armour & Co. in Chicago at $11.57 per 100 lb. This contract was completed and the price received compares favorably with the market quotations during that period.

During 1919 contracts for the sale of grease at the Chicago reduction plant ranged from 4 to 5½ ct. per pound with an average of 5.16 ct. on the total of 3,710,000 lb.

The last shipment on the above contracts was made Feb. 26, 1920.

During 1920 contracts were made totalling 1,440,000 lb., one-half of which was $5.75 per cwt. and one-half at $6 per cwt.

On the above orders there were delivered 20 carloads, amounting to 1,146,000 lb., leaving a balance of four carloads, or 298,000 lb. still on order but not shipped; the last shipment being made on Sept. 15, 1920. The prices received in 1920 were much less than that obtained for similar product sold by other cities during the same year.

The results obtained by the city of Chicago show that the contractors for grease during periods of high prices take their full contract poundage or more, but when prices are falling, they stop receiving their shipments. This is but natural, and unless the city is protected by surety bonds, the contractors will continue to take all the grease they can get when the market is rising and refuse to take their contracted amounts when the prices are falling, resulting in a loss to the city in either case.

There were three sales of tankage made during 1920, calling for 1,200, 5,500 and 1,000 tons, respectively, making a total of 7,700 tons. The last sale was made on Aug. 25. Of the total amount contracted for, there remained 1,500 tons undelivered, and of the order for 1,000 tons made Aug. 25, only 159.25 tons have been shipped.

The prices received for tankage during the past year amounted to from $7 to $8 per ton, which is low as compared with market conditions at time sales were made.

At the time of inspection, no shipments were being made and all tankage was being stored in piles adjoining the plant without milling or without having the grease extracted. This was made necessary on account of lack of storage facilities for grease and tankage. This condition would not have existed had shipments of products contracted for been completed.

Before the tankage stored on the prairie is marketed, it will have to be returned to the plant unless sold at a low price.. The rehandling will not only increase the costs of operation, but the material will depreciate so that original value will not be recoverable.

The price for by-products, such as tankage and grease, at the present time is very low and there is little demand. All garbage reduction plants, either privately or municipally operated, are now experiencing difficulty in disposing of their products except at low prices.

Chemical Laboratory.—This plant is provided with a chemical laboratory, which is well and properly equipped with apparatus. The work carried on in the laboratory consists in making analysis of samples turned over to the laboratory at the time of sales of by-products or the purchase of supplies for the plant, such as fuel oil or gasoline.

During the past year the products of tankage and grease have been sold as produced with no guarantee as to analysis so that it has not been necessary to make as extensive laboratory tests as would be required if they were sold on a basis of analysis.

The laboratory work is under the direction of the senior sanitary chemist at a salary of $2,220 per year. There is also employed in the laboratory an assistant and janitress, who are carried on the payroll as garbage handlers.

The cost of conducting the laboratory for payrolls and supplies amounts to approximately $5,500 per year, which is excessive for the volume of work handled, as it could be done under contract in a commercial laboratory for one-half that amount.

The chief advantage to be secured from maintaining a laboratory in connection with the plant is to carry on studies and research work in order to determine where betterments can be obtained, both as to quality of the by-products or as a check on the efficiency of the personnel in charge of operation; yet the laboratory has not been so used.

Unless the laboratory is used to its fullest advantage, it would be more economical and just as satisfactory to have the work done in a commercial laboratory or in other chemical laboratories maintained by the city.

Causes of High Costs.—The plant, as now constructed, could be operated at less cost. There is no one cause for the present excessive operating charges. They are many, and a summary of the principal factors contributing follows:

1. The equipment maintained is more extensive than justified by the volume of work handled.
2. The method of unloading and handling garbage at the receiving point is uneconomical.
3. The system of conveyors is complicated and requires considerable attention and repair.
4. The equipment is operated empty or below capacity at times when there is not sufficient load.
5. Steam and electric power is used unnecessarily when material is not being reduced, or for purposes not incident to plant operation.
6. Unnecessary expense is incurred because rubbish is not properly separated from the garbage.
7. Too many garbage handlers are carried on the payroll, who are assigned to jobs which do not occupy their full time or are non-productive.
8. The number of skilled laborers employed as mechanics and electricians is in excess of the needs of the plant.
9. The supervising force is in excess of the needs of the plant.
10. The overhead in connection with the maintenance of the office is excessive.
11. A full organization is carried unnecessarily at times when the plant is not in full operation.

No one individual is blamable for these things; they are rather the cumulative result of municipal management and the present physical condition of the plant.

Elsewhere in this report a comparison has been drawn between the operation of the Chicago reduction plant and that of the municipal plant at Cleveland. The reason for using Cleveland was that the total tonnage reduced annually compares more closely with that of Chicago than the total reduced by any other city. Furthermore, the Cleveland plant was the first to be municipally operated, and has been so used for the past 16 years. Thus the results achieved have undergone the test of time more fully than any other municipally operated plant. The data available is, therefore, more representative than that of any other city, as to what can be accomplished by municipal management and methods.

Although the "Digester" process, whereby the garbage is first cooked before drying, is not used in Chicago, yet the equipment used by Cleveland for drying and extracting is very similar. This difference of method, however, does not appreciably affect the basis for comparing results.

Comparison of Labor Distribution of Cleveland Municipal Plant with That of Chicago.—Although during the past year the quantity of garbage disposed of by Cleveland was within 12,000 tons of that handled by Chicago; and although the rate of wages paid in Cleveland was higher than in Chicago except in the case of mechanics; the payroll in Cleveland, nevertheless, was less than half. The following comparison of the organization of the employes in the two plants illustrates, in one way, why the Chicago plant is not as economically operated:

CLEVELAND.		CHICAGO.
68,645	Tons garbage reduced in 1920	[illegible]
	Superintendence.	
1 Superintendent.		1 Foreman in Charge
	Office.	
1 Clerk and Stenographer. 1 Bookkeeper. 1 Laboratory Assistant in City Chemical Laboratory. Note.—Bookkeeper keeps books for both Collection and Disposal.		1 Head Clerk. 1 Principal Clerk. 1 Senior Clerk. 1 Senior Clerk. 1 Junior Clerk. 2 Junior Stenographers. 1 Senior Sanitary Chemist 1 Assistant Chemist on Payroll as Garbage Handler. 1 Janitress, G. H. Payroll. 1 Office Assistant G. H. Payroll 1 Office Boy, G. H. Payroll.
	Foremen.	
3 General Foremen—one for each shift.		1 Assistant General Foreman. 1 Foreman Garbage Plant. 2 Foremen Garbage Handlers 1 Foreman Mill House. 1 Assistant Foreman Mill House 1 Foreman Extractor Plant (1 shift) or (3 shifts)
	Engineers.	
3 Engineers (1 for each shift) Power Plant (electric power generated).		1 Second Assistant Operating Engineer. 2 Third Assistant Operating Engineers. 9 Junior Operating Engineers 1 Hoisting Engineer (electric power purchased)
	Power House.	
3 Firemen. 3 Coal Passers. 1 Ash Handler.		4 Firemen 14 Garbage Handlers used in handling coal and ashes (day shift). 5 Garbage Handlers (2nd shift) 1 Garbage Handlers 3rd shift).
	Mechanics.	
2 Machinists. 3 Machinist Helpers. 2 Steamfitters. 1 Steamfitter Helper. 1 Carpenter. 1 Carpenter Helper. 1 Electrician.		8 Machinists 2 Steamfitters. 1 Steamfitter helper 2 Carpenters. 1 Blacksmith. 1 Blacksmith Helper. 6 Electricians (3 used on cranes)
	Operators	
11 Equipment Operators for dryers, digesters and extractors.		10 Equipment Operators for dryers, extractors, etc

None. [illegible] dition to Gar- [illegible]

Private vs. Public Operation. [illegible] municipal reduction plant can be [illegible] at the present time when the market prices for by-products are the [illegible] in the history of this business [illegible] practically double the 1914 rates; when all materials and supplies necessary for operation are more costly than ever before. True it is that some large municipalities have operated plants at a profit, but not by using the present methods and extensive equipment now in service at Chicago. Observation of the past performance of this work justified the conclusion that unless the operating costs are reduced the city of Chicago would gain by leasing the plant to a private corporation and contracting with the company for the disposal of the garbage as collected. If properly safeguarded, it is most probable that such an arrangement would prove more economical and satisfactory than the city's experience of the past.

Summary of Conclusions.—As a result of the studies and investigations made, the following conclusions are set forth:

1. That funds be provided to complete the piping of the new boiler plant.

2. That the necessary changes be made in drives of new extractors to permit their use.

3. That the vertical extractors be replaced where needed to give capacity additional to that which will be available when the new extractor plant is placed in operation.

4. That the six primary dryers in Dryer House No. 1 be replaced with new dryers to eliminate excessive maintenance cost and assure operation of the plant.

5. That the exhaust fans used with primary dryers be replaced.

6. That the necessary repairs be made to Cummer dryers in dryer house No. 2 to permit their operation.

7. That new crushers be installed in the receiving building to replace the two which are not serviceable.

8. That thorough tests be made to determine the cost of operation and the advantages and adaptability of the Atlas dyers, as installed in dryer houses Nos. 3, 4, and 5.

9. That studies be made of the cost of the different steps required in the operation of plant, with view to determining where economies can be effected.

10. That special attention be given to the construction and operation of conveyors and elevators in order to eliminate labor used in watching their performance to insure proper functioning.

11. That there be closer supervision of labor in order to improve its productive efficiency.

12. That economies be effected in the payroll by securing a greater productive efficiency of the organization rather than by reducing the rate of wages.

13. That the office force is in excess of that needed and that a force consisting of a principal clerk, senior clerk, stenographer and time keeper, and stenographer would be ample to conduct the office.

14. That the practice of carrying employes used in the office or in non-productive work as garbage handlers on payroll, should be discontinued.

15. [illegible] men employed be assigned to work as needed instead of carried for a particular task when the task does not require full time.

16. That the skilled mechanics steadily employed are in excess of the needs of the plant, and that during times when additional mechanics are needed they be employed temporarily, or the work be done on contract or order.

17. That when repairs to equipment are made in the municipal repair shop, the cost charged the municipal reduction plant should not be in excess of what the work could be done for under contract.

18. That the plant, as constructed, will require expenditure for operation and maintenance in excess of that found in other plants, due to extensive installation of equipment and methods of handling.

19. That more effort be made in improving the quantity and quality of by-products and that tests and studies be made to determine how affected by the different steps of the process.

20. That unless the chemical laboratory, in which research of control work is done, is used more fully, its operation be discontinued and the work handled by other laboratories, maintained by the city.

21. That more attention be given to the sales of by-products, and that a study of market conditions be made to determine the most desirable time to dispose of products.

22. That the city require sufficient bond at time of sales to guarantee fulfillment of contract by purchasers.

23. That all sales be made on competitive bids, either by advertising or by invitation.

24. That the sales of by-products be made on basis of analysis, as by so doing better prices will be secured and incentive to improve the quality of output will be evoked.

25. That special effort should be made to eliminate rubbish collected in the garbage, since it not only causes undue wear and tear on the equipment, but increases the operating cost for labor; and the final disposal of the rubbish by transporting to dumps entails a double haul.

26. That it would be desirable to provide types of collection equipment and facilities whereby wagons hauled to the plant can discharge load directly to storage pit without requiring cranes and labor for unloading, as at present.

27. That unless the present cost of operation is reduced, that steps be taken to determine what savings would result from leasing the plant and having the work done by contract.

Increasing Labor.—The report contains a diagram showing man days' labor of garbage handlers required to reduce one ton of garbage by months from January, 1915, to December, 1920. Approximate weighted average for the respective years are:

1915	0.25 man days per ton
1916	0.30 man days per ton
1917	[illegible] man days per ton
1918	[illegible] man days per ton
1919	[illegible] man days per ton
1920	[illegible] man days per ton

This increase in labor is coupled with a steady reduction in the amount of garbage handled as noted in the early part of the report.

Ground Water Supply in Santa Clara Valley, California—The U. S. Geological Survey has compiled a report on the water resources of the Santa Clara Valley. Manuscript copies are on file in its main office in Washington, D. C., and in its district office at 328 Custom House, San Francisco, where they can be consulted by hydraulic engineers or any others who may wish to use the data they contain.

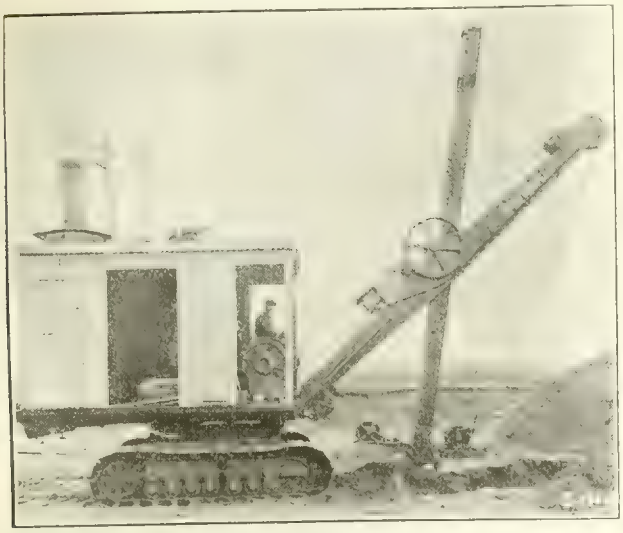
COMPARISON OF OPERATIONS BETWEEN THE CHICAGO MUNICIPAL REDUCTION PLANT AND THE CLEVELAND MUNICIPAL REDUCTION PLANT.

Year.	Total green garbage received in tons.	[illegible]	[illegible]	Percentage of tankage to green garbage.	Percentage of grease to green garbage.	Income per ton of green garbage from products.	Total net credit (+) or loss (—) per ton of green garbage.	Total operating expense. See Note "A."	Cost of operating per ton of green garbage. See Note "A."
				From Chicago Records.					
[illegible]	152,892					$1.19	—0.36	......	.
[illegible]	[illegible]		[illegible]	6.8	1.1	2.57	—0.56	..	
[illegible]	[illegible]		[illegible]	[illegible]	2.0	4.25	—0.31	$456,493	[illegible]
[illegible]	84,974		[illegible]	18.6	1.7	6.73	[illegible]	489,570	5.78
[illegible]	82,820		[illegible]	17.7	2.1	3.46	—3.17	548,687	6.63
[illegible]	80,132	[illegible]	[illegible]	14.2	1.1	2.56	—6.11	695,247	8.67
				From Cleveland Records.					
[illegible]	[illegible]		[illegible]	[illegible]	3.0	$3.60	+1.17	$151,503	[illegible]
1916	[illegible]		[illegible]	11.6	3.14	5.10	[illegible]	155,585	2.56
[illegible]	[illegible]	[illegible]	[illegible]	11.1	2.36	5.22	+1.81	191,001	3.41
[illegible]	[illegible]	[illegible]	[illegible]	11.0	2.56	7.58	+2.97	265,243	4.61
[illegible]	60,932	[illegible]	[illegible]	11.6	2.56	4.87	+ .96	238,202	3.91
[illegible]	68,645	[illegible]	[illegible]	10.5	2.45	6.06	+ .58	375,949	5.48

[illegible] included in figures tabulated for Cleveland but not for Chicago.
[illegible] garbage.

New "Steam Hoe" for Trench Excavation

After nearly five years of study, experiment and test of a patented device for trench excavation, the Ball Engine Co., of Erie, Pa., has just perfected and placed on the market the "Steam Hoe." This might be described as a "back acting steamshovel," for the dipper moves toward the machine in digging, and fills with a "hoe" motion, instead of being hoisted upward and outward. Since the dipper is loaded by pulling in toward the machine, a "steam hoe" backs away from the trench as it digs. Thus it works along always on solid ground, instead of being supported on a platform over the excavated trench. The "steam hoe's" ability to work on solid ground is of greatest advantage in soft or sandy material. On such excavation, it is claimed, the "steam hoe" not only does away with most of the cave-ins, but eliminates much of the trench-bracing.



Type B Erie Shovel, Equipped With "Steam Hoe" Attachment and 24-Ft. Dipper Stick.

While the "steam hoe" is especially adapted for soft and sandy soils, it is stated to be just as well suited for the hardest kinds of trench excavation—such as cutting through stiff shale, or large boulders. This work requires all the strength and power of a steam shovel, which the "steam hoe" affords. Equipped with 22 ft. dipper handle, the Erie "steam hoe" digs trench as deep as 14 ft. When digging trench of this depth, it is best to carry the boom at 40 degrees with the horizontal. At this angle, it is claimed, the "steam hoe," with 22 ft. dipper handle, can dump material 13 ft. 9 in. above grade and 33 ft. from the center shaft. Excavated material is piled high, well away from the trench. By means of the power-driven worm gear operated boom hoist, the boom can be quickly set at the most effective digging angle.

In ordinary materials such as earth or gravel, it is stated, the "steam hoe" easily gives an output of 200 to 300 cu. yd. a day in trench excavation. The machine is very quick-acting, with the same simple control that has proved so successful on the Erie steam shovel. The Erie "steam hoe" is furnished with either traction wheel or caterpillar-type mounting, the two types of mounting being interchangeable on the same truck frame. Another valuable feature of this machine is its ready convertibility to either a steam shovel or a locomotive crane.

Bibliography of Activated Sludge Process of Sewage Treatment

A very comprehensive bibliography of the activated sludge process of sewage treatment has just been issued by the General Filtration Co., Rochester, N. Y. It is compiled from the various periodicals and brought down to the close of the year 1920. It supplants an earlier edition and contains a list of over 600 articles, about 400 more than the previous edition. Brief abstracts of each article give a general idea as to the nature of the contents. In it is included a list of the patents covering the process and also a very complete list of contributors and authors. In compiling the index, the idea has been to keep a chronological order in arrangement. An index of the location of plants with a brief description furnishes an idea as to the extent of work actually done on the process. The bibliography sells for $1 net.

Cut Production Costs With Modern Equipment

There is a hoary old story of the shiftless farmer whose house had a very leaky roof. When it was fair it didn't need fixing—and when it rained of course he couldn't fix it until it cleared up.

It's the same way with too many machine shops throughout the country. Their leaky roofs are in the shape of poor machine equipment. When demand is good buyers will pay a high price for their product, and they feel they do not need to put in new machinery.

But when business is slack and they feel they cannot buy—that is the time when their poor equipment counts most against them. They cannot meet competition and the business goes to those who have proper machinery for producing work at low cost.

These lame ducks always think that the successful bidder must be losing money at the prices he bids for work. They are very apt to call it cut-throat competition, when in reality it is simply foresight and good management in having up-to-date shop equipment.

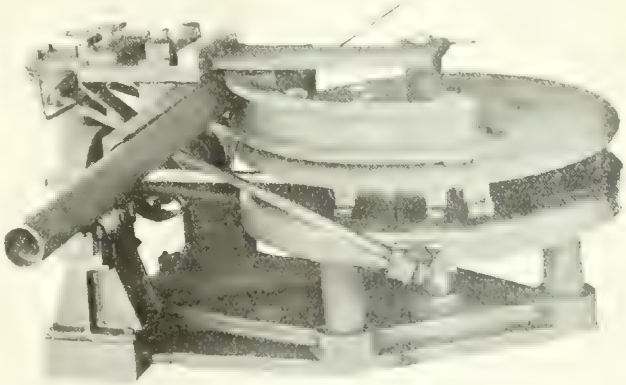
In one recent case of this kind a contract was taken at what seemed a very low figure and the high bidder protested that it could not be made for the price asked. So the successful bidder showed his shop time on the job to be 48 hours, as against the other bidder's estimate of 155 hours. A comparison showed modern equipment in one plant—out-of-date machinery in the other.

Now is the time to look over your equipment with the same critical eye as though you were appraising a competitor; to ask yourself whether you can afford to let business go to the other shop because of its better equipment. Production costs must be brought down by the use of the best machinery possible.—Editorial in Power.

New Pipe Bending Machine

A new power driven machine for bending standard iron pipe or tubing up to 4 in. pipe size has been placed on the market by the Wallace Supplies Mfg. Co., 418 Orleans St., Chicago, Ill.

In this machine the roller bracket is adjustable to take forms up to 48-in. diameter and is operated with eccentric lever to force tube or pipe into groove or form for holding the outside follower bar close to the tube. The machine is operated by lever-engaging friction-clutch pulleys for forward and reverse drive. Adjustable stops are provided to suit any degree of bend required. Clutch is automatically thrown out of engagement at both the end of the bending operation and when the machine has been reversed to the starting position. Special forms with inside follower bars or floating mandrels can be furnished to order for bending light gage tubing to a short radius without flattening or crimping. Standard equipment furnished with this machine consists of the following:

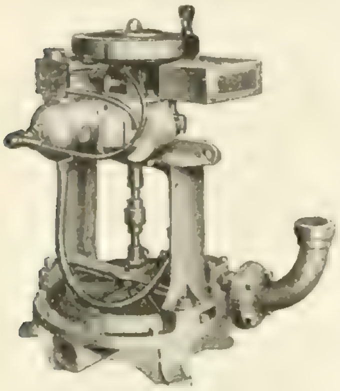


Power Driven Pipe and Tube Bending Machine.

1 form for bending 1½-in. iron pipe to 9 in. radius, 90 degrees
1 form for bending 2-in. iron pipe to 12 in. radius, 90 degrees
1 form for bending 2½-in. iron pipe to 15 in. radius, 90 degrees
1 form for bending 3-in. iron pipe to 18 in. radius, 90 degrees
1 form for bending 3½-in. iron pipe to 21 in. radius, 90 degrees
1 form for bending 4-in. iron pipe to 24 in. radius, 90 degrees

Bends can be made cold with [illegible] and with out the use of an inside follower [illegible] special forms and floating mandrel, [illegible] extension arm can be furnished to suit specifications. The pipe is secured to the form by means of strap and eccentric lever and both the inside follower and the [illegible] with the proper thickness to secure the best possible results. The outside follower bar operates between the tube and roller instead of working directly on the tube. Special equipment can be furnished for bending angles round, flat, channels, tees, or flat on edge and special section.

New Developments in Evinrude Centrifugal Pump



Evinrude Centrifugal Pump.

Important new developments have been introduced in the Evinrude centrifugal pump, which has been manufactured for the last four years by the Evinrude Motor Co., Milwaukee, Wis. As shown in the illustration, the frame is provided with right-angle brackets on both sides to permit bolting in wood stringers, for carrying purposes. In addition, there is a large hole in each side of the frame for the insertion of a hoisting cable or rope. This makes it possible to lower the pump right down into the excavation and submerge it in the liquid. It is, however, not necessary to do this as the Evinrude centrifugal pump can very easily handle suction lifts up to 20 ft. A new, large water screen prevents the water circulation from becoming clogged. The discharge elbow is heavier, and is provided with a female instead of male thread as formerly, the new arrangement being much stronger. The exhaust pipe is of approved, sturdy design. A universal joint connects the power plant with the pump. By means of the universal joint, the sideplay on the bearings of the motor and the pump is entirely eliminated, thereby lengthening the life of the pump. The lugs or feet for bolting down the pump, are particularly notable, as with them the pump can be bolted down securely to a wooden platform or floor.

Garbage Disposal in Leading Cities of U. S.

In a report on the disposal of city wastes of Baltimore, Md., submitted April 9 by Mr. H. G. Perring, City Engineer, the following tabulation compiled in 1920 by Mr. John A. Griffin, City Engineer of Los Angeles, Calif., is included:

GENERAL DATA ON GARBAGE DISPOSAL IN LEADING CITIES OF THE UNITED STATES.

City.	Population contributing.	Method of disposal.
Albany, N. Y.	100,000	Fed to hogs.
Akron, Ohio	176,000	Reduction, from 1916 to March, 1920. Fed to hogs since March, 1920.
Boston, Mass.	750,000	Part by reduction. Part by hog feeding.
[illegible], Conn.	100,000	Reduction.
[illegible], Ill.	600,000	Reduction.
[illegible], Ohio	.	Reduction.
[illegible]	[illegible]	Fed to hogs.
[illegible]	[illegible]	Reduction.
[illegible], Mass.	[illegible]	Fed to hogs.
[illegible]	[illegible]	One-third incinerated. Two-thirds placed on dumps.
[illegible]	[illegible]	
[illegible]	[illegible]	Reduction.
[illegible]	[illegible]	To farmers.
[illegible]		To farmers for hog feeding.
[illegible]		Incineration.
Minneapolis, Minn.†	[illegible]	Fed to hogs by contractors.
[illegible]	146,000	Fed to hogs.
Philadelphia, Pa.	1,[illegible]	[illegible]
[illegible]	583,000	[illegible]
Portland, Ore.	258,000	Incineration.
[illegible], R. I.	....	Fed to hogs.
[illegible]	107,000	Reduction.
[illegible]	161,000	Dump.
		[illegible]
[illegible]	[illegible]	Fed to hogs
[illegible]	[illegible]	[illegible]
Washington, D. C.	400,000	Reduction.
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

CITIES COMBINING THE COLLECTION OF GARBAGE WITH THE COLLECTION OF OTHER CITY WASTES.

City.	Population contributing.	Method of disposal.
Elizabeth, N. J.	100,000	Dumped on low, marshy grounds.
Memphis, Tenn.	163,000	
New Orleans, La.	387,000	Incineration and dump.
San Francisco, Cal.	....	Residence garbage incinerated. Business garbage fed to hogs.
Seattle, Wash.***	299,860	Sanitary fill.
Tacoma, Wash.††	60,000	Sanitary fill.
Trenton, N. J.	115,000	Incineration.
Troy, N. Y.	80,000	Buried under ashes and other municipal wastes.

*Garbage collected and disposed of by contract at cost of $69,000 to the city. †Discontinuance of feeding ordered by District Court May, 1920. **Hotel and restaurant garbage sold to hog raisers. No revenue to city. ††Tell system. Each householder pays contractor for amount collected.

Irrigation from Wells in Santa Clara Valley—Nearly all the fruit orchards in the Santa Clara Valley, California, which borders the south end of San Francisco Bay, and is the home of the famous Santa Clara prune, are irrigated with water pumped from wells. The U. S. Geological Survey has estimated that in 1919 about 120,000 acre-feet of water were obtained from pumping plants and flowing wells in Santa Clara Valley for irrigation. This is nearly 40 billion gallons, equivalent to a continuous draft of more than 100 million gallons a day. In addition to the water used for irrigation more than 25,000 acre-feet was pumped in 1919 for industrial supplies and public waterworks, many millions of gallons having been pumped out of the valley to supply Oakland and other cities on the east side of the bay.

Personals

W. H. Larson, who has been county highway superintendent of Union County, South Dakota, for the past year, has gone to Pierre, where he has been appointed county highway superintendent of Hughes County. L. J. Johnson of Elk Point will succeed Mr. Larson as highway superintendent of Union County.

Paul P. Haynens, late a member of the Public Service Commission of Indiana, and Carl H. Mote, late secretary of the Public Service Commission of Indiana, have entered into a partnership for the practice of law with offices at 112 Hume-Mansur Bldg., Indianapolis. They will engage especially in the practice before regulatory bodies.

Perry T. Naylor has been appointed city engineer of Hastings, Neb. He has been assistant city engineer for about a year and a half. Previous to his coming to Hastings he was with the Strathmore Paper Co., Springfield, Mass., as a construction engineer. He was with the 211th Engineers in the war. Before the war he was assistant chief engineer for the Springfield Street Ry. Co. and Worcester Consolidated Street Ry. Co., with office at Springfield, Mass.

John J. Swan has become associated with the Engineering Business Exchange of New York City and has removed there from Indianapolis, resigning his position with the Prest-O-Lite Co., which he has held for two years past. Mr. Swan was graduated from Cornell in 1897. He was for a time one of the editors of Engineering News and later held important engineering and executive positions with well-known industrial companies, including the Ingersoll-Rand Co., the Longmead Iron Co., the Chicago Pneumatic Tool Co., Keller Mfg. Co., and the American Arms Corporation.

Charles H. MacDowell was elected president of the Western Society of Engineers at the election held May 4. Mr. MacDowell is president of the Armour Fertilizer Works and brings to this position a wide experience as an executive. The other officers elected are: First vice-president, Julius L. Hecht, assistant to vice-president, Public Service Co. of Northern Illinois; second vice-president, F. F. Fowle, consulting and mechanical engineer; third vice-president, Benjamin B. Shapiro, consulting structural engineer; treasurer, Homer E. Niesz, manager of industrial relations, Commonwealth Edison Co.; trustee, Edwin W. Allen, assistant district manager and district engineer, General Electric Co. Members of Washington Award Commission—John F. Hayford, director, School of Engineering, Northwestern University; Henry J. Burt, manager, Holabird & Roche.

Homer J. Forsythe, manager of the construction division of the engineering department of the duPont Company, has been transferred to the position of assistant general manager of the Hyatt Roller Bearing Co., of Newark, N. J., a subsidiary of the General Motors Corporation. Mr. Forsythe was selected for this important position because of his wide experience in machine shop work and his ability to handle difficult problems in his line. He had been with the engineering department of the duPont Co. since August, 1906, when he started work at the Wilmington office in the capacity of estimator. Later he occupied executive positions at the Brandywine shops at Wilmington and became recognized as one of the important men in the engineering department. During the war he was made manager of the combined Wilmington shops which were one of the major divisions of the duPont Engineering Co. engaged in the construction of material for the war plants. At the end of the war he was promoted to manager of the construction division of the engineering department, which position he held until his recent transfer.

Industrial Notes

The Byers Machine Co., Ravenna, O., has opened the following direct sales offices for its cranes and hoist: New York—E. W. S. Elmes, district manager, Room 704, 30 Church St., New York, N. Y. St. Louis—Frank E. Miner, district manager, Room 700, Rialto Bldg., St. Louis, Mo.

The corporate name of Rickard & Sloan has been changed to Rickard & Co., Inc. Continuing the policy which, to a large degree, has been responsible for its uninterrupted growth, the company will specialize in industrial and technical advertising. The officers are: W. L. Rickard, president; O. S. Tyson, vice-president; Julian Gran, treasurer; L. F. Maher, secretary.

Railways and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Common Carriers and the Highways

The accepted proposition that a public road is for the impartial benefit of all the public is simple in words but complicated in application because of uncertainties of interpretation of the term "impartial." Mr. Julius Kruttschnitt, chairman of the Board of the Southern Pacific Railway, complains bitterly to the Senate Committee on Interstate Commerce that the highways are being used for common carrier purposes. Protest on the same use is filed with the Public Utilities Commission of Illinois by the Chicago, Rock Island & Pacific Ry., and we hear other similar complaints. Mr. Kruttschnitt also makes other expostulations, and his recommendations for measures of railway relief are quoted as follows:

> Stop the use for common carrier purposes of highways built with public moneys without adequate tolls and proper regulations.
>
> Make inland waterways built or improved at public expense carry themselves as to interest on cost and maintenance by regulating the common carrier traffic on them and by imposing adequate tolls.
>
> Keep the government out of the business of operating steamships and stop the lavish expenditure of public money to provide coast to coast ocean transportation in competition with transcontinental railroads.
>
> Tolls for use of the Panama canal should be sufficient to pay interest on its cost, operating expenses and maintenance.
>
> Do not deprive transcontinental carriers of coast to coast traffic by inflexibly enforcing a strict long and short haul clause.

The apparent selfishness of Mr. Kruttschnitt's motives is not in itself an argument against what he asks. It is but a conspicuous illustration of the character of most business motives, and applies about equally to the lowest paid laborer and to the greatest capitalist.

Mr. Kruttschnitt's words leave the impression that he thinks that transportation of freight and passengers on our public highways by land and by water should be subject to a tax which would afford to the railways a measure of protection from competition. This suggestion has been offered before, and if Mr. Kruttschnitt means otherwise, it is unfortunate that he was not more explicit or perhaps that he was not more fully quoted by the newspapers. Engineering and Contracting cannot agree that such protection is desirable. We hold that highway users should pay as nearly as possible the full cost of their use in depreciation and maintenance, and usually a portion of the interest costs as well; but a protective tax or toll is a bar to progress, and a measure which we do not believe the public would tolerate.

Instead of restricting the use of our highways, that use should be encouraged and facilitated. When the public finds in any given case that the highway is preferable to the railway whether because of economy, convenience or pleasure, it seems to us very clear that it is entitled to have such use. When persons desirous of regulating railway income to the lowest possible point have contended that such a course was just because the government in effect guaranteed the return through its regulation, the railways promptly denied the existence of any guarantee either practical or implied. In this contention Engineering and Contracting always supported the roads, and held that they should be granted a rate of return substantially more than a mere interest rate. We believe the present condition of the roads affords evidence of the soundness of this position, and we shall continue to advocate more liberal treatment for them and for other public utilities.

Prevention of competition is sometimes a desirable thing—not merely from the viewpoint of the parties protected, but also as a measure of public economy. When, however, protection stops the use of improved methods it becomes an impediment to progress which is hard to justify. We have not hesitated to condemn British labor unions for their attitude in restricting the use of labor-saving machinery, and we cannot approve restrictions on the economic use of our own highways.

We have already stated the desirability of payment in accordance with the use of highways. The difficulties of assessing and collecting such payment are many, but do not excuse failure to solve the problem in the most practical manner possible. In spite of its inconvenience there is still the possibility of a revival of the toll road. The question of regulation is quite another one. It seems evident that a highway user who is in effect a common carrier should be sub-

[illegible] to regulation in the same manner [illegible] official bodies as the railways. In fact there is much to be said in favor of requiring such users to operate under franchises in a fashion similar to the street railways, but usually without the exclusive feature of railway franchises. The public has come to look upon all its utilities as natural monopolies, but here is a field in which an advantageous competition seems possible, and may well be tested out.

With regard to the adjustment of Panama Canal tolls we need only comment that the same general principle applies as on the highways: tolls should be such as will afford the greatest economic benefit to the nation as a whole. Because the canal was built partly as a military measure, a failure to collect full interest, maintenance and operation costs would be of different significance than in the case of a public improvement of no military purpose.

The inland waterways present still another problem. Mr. Kruttschnitt says: "Make them carry themselves as to interest and maintenance." Alas that in too many instances this cannot be done! Many a waterway should never have been made, and being made, can never be an economic investment to the community. Since the investment can not now be recovered, tolls on such waterways should be adjusted to bring a maximum income, and if this exceeds the operating expense and maintenance, the route will survive, while the interest losses are pocketed with a grin. If an improvement cannot earn its operation and maintenance, and is without prospect of development to such earning, then the sooner it is abandoned the better. As to future waterways we can only hope that pork barrel politics will be restrained from building more that are primarily sink holes for public funds.

In regard to the highway situation we wish to call attention to one further consideration—the function of the highways as railway feeders. In performing this service they develop territory, and both directly and indirectly bring business to the railways. For long-haul traffic we believe the railways will always be preferred to the highways, and it is not to be overlooked that railway branch lines have in many cases proved of value to the roads only through their service as main line feeders. May it not be that after all the motor truck will prove of benefit rather than harm to the steam and electric roads?

Voices of Optimism

The daily press of May 11 and 12 gives us the following:

By Herbert Hoover, U. S. Secretary of Commerce:

"I am convinced that we have fundamentally turned the corner."

* * *

"It would be foolish not to acknowledge frankly that we are in the midst of great economic difficulties. But it is infinitely more foolish for anyone to think we will not grow out of them."

* * *

"With the intelligence, productive power and resourcefulness of the American people, we will emerge through all this, but the rapidity with which we recover will depend upon the promptness with which we grasp and well understand the nature of our difficulties and upon the unity and energy of our action."

By John L. Lewis, President of the United Mine Workers of America:

"It is my opinion we are emerging from the crisis and that the indications are we soon will witness a substantial improvement. I am optimistic enough to believe that ere long our nation will again become the active workshop of the world."

By James J. Davis, U. S. Secretary of Labor:

"I believe the greatest 20 years we are ever going to see in the United States are ahead of us, and I believe with all my heart that we are going to have 20 years of peace and prosperity."

* * *

"Nevertheless, the principle of conciliation is gaining. We are fortunate to have it, no matter how it came to us."

By Giovanni Giolitti, Premier of Italy:

"Mustering all her available forces, Italy faces the future with faith and certainty. She is assured of sound financial policy and healthy industrial activity, as well as increasing commerce."

The editors of Engineering and Contracting have deplored the occasional appearance of a very evident propaganda of optimism, for a worthy end is not well served by misstated or misconstrued facts or by specious argument. Here are statements whose sincerity is emphasized by the fact that with each of them there were acknowledgments of sobering and regrettable facts and conditions, and admonitions to increased efforts and efficiency.

The Construction Scandal

Engineering and Contracting has little to say regarding the widespread corruption in the building industries of New York and Chicago which is now unquestionably proved. With what has already been developed, and without waiting for the whole story to be told, we are presented with a sickening picture of graft, conspiracy, "double cross" and "frame up," about which we might moralize at interminable length and to very little practical good.

Loss of faith in human nature is an old reaction from such disclosures, but it is not permanent. When we sober our thoughts we know that honest men still live in the ranks of both capital and labor, and that even unselfishness is sometimes to be found.

Among the wicked, exhortations to virtue avail little. A few respond to the doctrine of "Honesty the best policy." The good have some power to remedy the situation—not to speedily cure it. If the good will preserve the utmost vigilance; if they will constantly bear in mind that the thieves are as energetic and as smart as they, and having developed their minds in dishonesty, will find opportunities which the good are most likely to miss; most of all, if they will courageously stand for their rights and the right of their business; if they will make in some cases a present sacrifice for a future, lasting benefit, and if they will skilfully and wholeheartedly co-operate, they will put themselves beyond the necessity of paying a shameful and expensive tribute, and will have the satisfaction of knowing that they are making the building industry as clean as any. Only the high courage and patience which have gone into every great success will succeed here.

A Great Chief Retires

William Hood, age 75, railroad engineer 54 years, chief engineer 37 years, resigned on May 3 from his long standing position with the Southern Pacific Co. He does not, however, retire to ruminate quietly upon the achievements of his earlier life. His employer wished him to continue in his old capacity, but had little attractive new work to offer, wherefore Mr. Hood leaves them to enter a private practice in which there are more of the problems which keep life from going stale.

Aside from his engineering talents, Mr. Hood's best known qualities are his love of nature, his broad mindedness, and his kindly disposition. It is said that while chief engineer of the Southern Pacific he was never too busy to reply to a letter or to receive a caller.

We glance at some of Mr. Hood's spectacular works without in any way forgetting that they were carried out only because they afforded the most economic solution of the respective problems; and that Mr. Hood's greatness, like that of any other engineer, is better measured in terms of the mighty structures whose building he avoided. In the "Tehachapi Loop" he circled a mountain peak, crossing his line through a tunnel. The trick is old now, but it took vision in the seventies, and saved the railroad a huge sum. Vision and courage were both needed to cross Salt Lake with the "Lucin Cut-off," yet Hood found the economic advantage sufficient to meet the engineering obstacles, and he carried his point over the objections of many engineers. The intricacy of the problems which he solved in locating the Southern Pacific line in the Sacramento Canyon, and the line of the San Diego and Arizona Railroad through Carriso Gorge must be seen and studied to be appreciated.

We imagine that like most great men Hood says there is no "secret" of success. His unfailing industry is conspicuous; his keeness of perception and his great memory are not concealed; his imagination and his kindliness have been commented upon. Of these and other qualities one of the most important, and probably the least considered is that of memory. He has a marvelous knowledge of topographical detail of the country through which the Southern Pacific passes and of much country to which it may properly extend. It is said, in fact, that he is intimately acquainted with every portion of the 11,000 miles of that system, and one can not doubt that this knowledge has been of great value at all times. In the days of sharp competition for new territory, it was inestimable.

We should do an injustice to Mr. Hood were we to fail to acknowledge his service to his country. At the age of sixteen he broke off preparation for college to enlist in the 46th Massachusetts Volunteers, and with them he participated in some of the hardest fought battles of the Civil War. He entered college, but left without completing his course to join the builders of the Central Pacific Railroad—the first transcontinental line.

In announcing Mr. Hood's retirement, President Sproule of the Southern Pacific Co., issued the following statement:

"Mr. Hood asked us last year to allow him to retire upon the completion of his 54th year in the service of this company. This is in accordance with his decision to become free from the cares and responsibilities of his official position. His repeatedly expressed desire the company respects and Mr. Hood will retire on a well-earned pension. He closes his active service after a brilliant and valiant career and he will carry into retirement the respect and admiration of his associates and a recognition that Mr. Hood, by length of service and by brilliancy of attainments, stands in the front rank of railroad engineers and the engineering profession."

Edison's Intelligence Tests Are Incomplete

After having noted Mr. Edison's famous questions to prospective apprentices probably few of our readers have failed to be impressed with their own "amazing ignorance." By propounding these questions, Edison has not only accomplished the primary purpose of segregating the sheep from the goats among the aspiring candidates for admission to the outer circles of his temple, but he has performed a salutary service in humbling an overproud human nature. It is only to be regretted that his list of questions was not longer.

Fully realizing our own inadequacy for such a task, but sincerely desirous of helping humanity in every way possible, Engineering and Contracting offers a supplementary list of ten questions, and hopes that other public-spirited organizations and individuals will proceed along similar lines until the standard of intelligence is thoroughly established.

1. Who was the author of the Book of Zachariah?
2. What is the highest mountain in South Dakota?
3. In five-handed deuces wild, what is your chance of winning on a draw to three queens after two players have passed, one has stood pat, and the fourth has drawn three cards?
4. What is the full name of the present Ameer of Afghanistan?
5. What smells worse than a glue factory?
6. Why do girls cover their pretty ears with their hair?
7. What is a chersonese?
8. Who founded Paducah, Kentucky?
9. How is counterfeit money made?
10. What is the chemical composition of tabasco sauce?

Regulation vs. Competition for Public Utilities

According to a recent telegram from the Northwest, a movement has been started to invoke the referendum on the so-called "Certificate of Necessity and Convenience Act" passed by the last Washington legislature. This act as finally adopted in 1920, represented the hard-fought victory of those who believe in commission regulation rather than competition as the best safeguard for public interests in securing adequate and economic service. It brought to Washington the policy which has long been established under California rulings—that of requiring the consent of the regulating commission before a public utility may enter the district already served by another company. The idea back of it is that duplication of equipment and personnel in the end must be paid for by the public, either in supporting two successful companies, or in higher rates paid to the company which wins out by purchasing the other.

The principle of recognizing the natural monopoly of public utility concerns so long as they render adequate and reasonable service has proved its worth in practice and in California at least, after nine years in use, may be regarded as established. It is significant that the recent investigating committee from the California State Legislature who started their inquistion of the Railroad Commission of that state with the avowed disapproval of this principle, were completely converted by their investigations and express this stand in their final report:

> Competition in public utility service is fundamentally wasteful. A territory well served (conceding that regulation regulates and compels good service) by any utility, cannot be better or more economically served by two or more utility concerns.

And in another place they state that, in the absence of public ownership, the committee "is of the opinion that . . . the only solution of the problem is through regulated monopolies."

The Journal of Electricity and Western Industry considers this principle the foundation stone of successful regulation. It is greatly to be hoped that the efforts to retract this forward step in Washington will not prove successful. —Editorial in Journal of Electricity and Western Industry.

Rail Statistics for 1920

The American Iron and Steel Institute reports the production of rails in the United States in 1920 at 2,604,116 gross tons, against 2,203,843 tons in 1919, about 1,900,000 tons in 1908 and 1914 and 3,977,887 tons in 1906, the record year for rail production. The production of late has been entirely of steel rails, the last iron rail production reported being 234 tons, in 1911. The rails made in 1920 were chiefly priced at $45 for Bessemer and $47 for open-hearth, and higher, against prices of $28 for bessemer and $30 for open-hearth for many years prior to May 1, 1916.

The production of rails is not an index of railroad prosperity to anything like the extent that is commonly assumed. Of all classes of material bought by railroads, rails are among the least promising of increased revenue and the most dangerous to do without when needed. Ten years ago a much smaller tonnage of the total output was used for replacements than at present, while large tonnages were used for building new track. Long ago one function of branch lines of railroad was to remove the necessity of driving wagons through mud. The motor vehicle and highway improvement have filled that bill very largely, furnishing one of several reasons why additional branch lines are not built to so great an extent as formerly.

The decrease in the consumption of rails by the standard steam roads is really greater than appears from the production statistics. In 1906 total production was 3,977,887 tons, rail exports amounted to 328,036 tons, imports being 4,943 tons, while 284,612 tons of rails under 45 lb. per yard were made, an unknown proportion of these light rails being exported. The domestic consumption of rails 45 lb. and over was therefore about 3,500,000 tons. In 1920 production was 2,604,116 tons, including 489,043 tons of rails under 50 lb. per yard, exports were 594,634 tons and imports were 45,684 tons, making the domestic consumption of rails 50 lb. and over probably under 1,750,000 tons, or a decrease of 50 per cent from 1906, whereas the total production declined by only about 35 per cent. The increase in the manufacture of light rails in the fourteen years, 60 or 65 per cent, is an interesting point.

The domestic consumption of standard section rails last year was of course almost wholly for replacement purposes. The building of new line dwindled to insignificant proportions several years ago, and the laying of additional track has been very small of late. The occasion for rail replacement is not in all cases simply normal wear. On account of heavier wheel loads the requirements in a rail increase. The old rail deteriorates rapidly and is replaced by a rail that will bear up better. The improvement is partly in quality and partly by increasing the section. Twenty years ago the 100-lb. rail was a rarity, but in 1920 729,118 tons of rails were rolled in sections 100 lb. and over.

Titanium-treated rails came back a trifle in 1920, the tonnage so treated being 11,652 tons, against 6,207 tons in 1919 and 2,891 tons in 1918, the low year for titanium. In 1910 256,759 tons of rails were made with titanium treatment, but three years later less than one-fifth as many tons.—Editorial in Chemical and Metallurgical Engineering.

Labor Unionism and Prosperity

Before the annual meeting of the United States Steel Corporation last Monday Judge Gary said: "I firmly believe complete unionization of the industry of this country would be the beginning of industrial decay" and that success of the labor union program "would be the control of shop, then the general management of the business, then of capital and finally the government." What has occurred in England in the past few days gives point to this utterance. To what else has labor unionism in Britain been tending?

Judge Gary might have pointed out that prior to 1890 the United Kingdom made more pig iron than the United States, while at the present time we have four times the British capacity. What are the causes of this change? Engineering skill is available in each country. Metallurgical facts are known. Britain must import some iron ore, but we move iron ore a greater distance within our borders. One great difference between the industries in the two countries has been that in the United States the men follow the machinery while in the British industry usually they do not. Often in conversations between American and British manufacturers the American has asked, "Why do you not adopt this machinery?" and the reply has been, "Our men would not get the results from it." A debater who supported the proposition that the chief reason for the American iron industry's growth to four times the size of the British iron industry in 30 years is that this country has had the open shop and Great Britain the closed shop, would have a strong case, even though required to base it on this one argument against the whole field of arguments.

Prosperity consists in advancement of the people in material things. If in a year a household acquires more new furniture and carpets than enough to balance the wear of the existing equipment it has prospered in this respect. If the individual's clothing is of better quality or in better condition at the end of a year than at the beginning he has prospered in that regard. If the family is able to live in a better house it is prospering. If these things come to all the people the country is prospering.

If all the tailors unite to make one-half as much clothing as formerly, if all the furniture factory workmen arrange to produce one-half as much furniture, if the artisans in the building trades bring it about that houses are erected at one-half the former speed, measured in man days—if such a thing is done by workers all along the line, the people have so much less prosperity and advancement. It does not matter an iota, considering the thing collectively, what the rates of wages are or the prices or costs of things. The people cannot enjoy things if they are not brought into being.

The practice of unionism has been to multiply the number of jobs and reduce the amount of service performed in a day. The loss must be borne by some one. It cannot be borne by the employer's profit. The workman may think so when excited by the soap box orator, but an analysis of the total paid in wages and salaries, and of the total of actual profits susceptible of diminution without throttling industry, would show such an extreme disproportion that the futility of the ambition would be apparent.

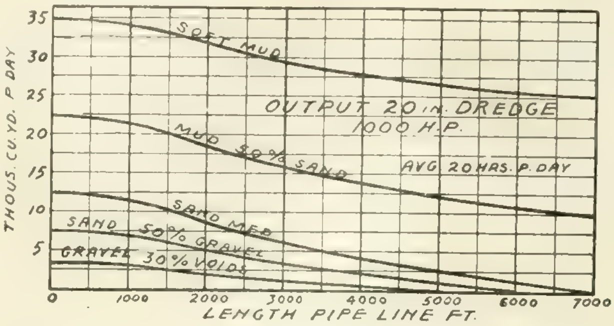
When, however, the proportion of all industry that is dominated by unionism is small, the unions have all the other workers as the field for their exploitation. At the present time the members of unions are about one-tenth of all the workers. If the proportion were reversed the process would not work, and as Judge Gary said in his address there would be industrial decay.—From an editorial in The Iron Age.

Chicago as a Rail-Water Gateway.—One of the sessions of the spring meeting of the American Society of Mechanical Engineers, which is to be held at the Congress Hotel, Chicago, May 23-26, will be devoted to the problems of Chicago as a mid-western rail-water gateway. At this session, which will be on May 25, the following papers will be presented: "Some Aspects of the Problem of Chicago as the Mid-Interior Rail-Water Gateway," J. R. Bibbins; "Development of Air Rights in Connection with City Freight Houses," E. J. Noonan; "Freight Movement by Motor Trucks, Viewpoint of Carrier and Public," Hugh E. Young; "Freight-Tunnel System as a Terminal Distribution Agency," J. R. Bibbins and E. J. Noonan; "The Function of the Terminal Survey," J. R. Bibbins; "The Relation of Steam Roads to Rapid Transit Development," Bion J. Arnold.

Hydraulic Dredge Output

By CHARLES EVAN FOWLER,
Consulting Engineer, New York City.

The output of hydraulic dredges is dependent upon so many factors that published data of one particular piece of work are of limited value in determining the output of a different dredge for other classes of material. The earlier dredges used by the writer over 20 years ago, were very deficient in engine power and a 20-in. dredge with only 450 h.p. gave very good results for mud or light sand, but was sadly out of place for pipe lines of over 3,000 ft., or for pumping gravel with a pipe line of even less than 1,000 ft. The material handled on one piece of work involving nearly 20,000,000 cu. yd. was a moderately fine volcanic sand and was very clean. The average output per day for a 3,000 ft. pipe line was about 3,500 cu. yd., for an average daily running time of 19 pumping hours. When the pipe line was lengthened to practically one mile, the output dropped to about 1,200 cu. yd. per day. The same sand was handled by an 800 h.p. suction dredge with 20-in. pipe line, through a 1,000 ft. length of pipe at the rate of over 8,000 cu. yd. per day, but with an average running time of 21 hours daily.



Output of 20-in. Dredge for Various Classes of Material.

The diagram herewith shows the output of a 20-in. dredge with a 1,000 h.p. triple expansion engine, and the curve for medium sand would represent its output for about the same class of material as was described in the preceding paragraph, which output for sand would be about the same as shown by the sand and gravel curve on the diagram. This indicates how very important it is to have real horse power to operate a 20 in. pump, and a 1,000 h.p. engine or variable speed motor is the least that should be considered for this size of dredge, or enough power to give about 50 lb. per square inch pressure on the pipe line. The lighter grades of material such as mud or fine sand are largely carried in suspension, and while such a pressure means a large balance on the right side of the ledger, it becomes a real necessity if paying quantities of heavy sand, sand and gravel, or gravel are to be pumped. These heavier materials are not carried in suspension to such a great percentage as for the light materials, and a large proportion of them drop to the bottom of the pipe and must be actually boosted along.

The effect of the percentage of floating or pontoon line to the total length of the pipe line has not been determined closely in the amount pumped, but it is certain that the drop in the output as shown by the curves for pipe lines from 2,000 to 4,000 ft., is due to some extent to the increased friction of the sleeve couplings of the pontoon line. The writer does not believe in abandoning such a good operating device as the rubber sleeve connections, but has always found it desirable to keep the length down to a minimum for the pontoon line proper, and has accomplished this by making considerable of the floating line by using stove pipe on log rafts, or else shore pipe carried on pile cribbing where the water is shallow.

The diagram ends at 7,000 ft. length of pipe line, and beyond that point for lighter materials the curves will soon begin to reverse and reduce to zero output; so that when this reverse in the curve becomes marked it is time to install booster plants if the material is to be carried farther. The curves for the output of heavier material are carried out to zero, but long before this is reached the economical length of pipe line will have been passed. This length of line may be taken as 5,000 ft. for heavy sand, 4,000 ft. for sand and gravel, and 2,000 ft. for gravel.

Scientific and Engineering Work of the Government Its Cost and Its Value

In a paper presented at a meeting of the Washington Section of the American Society of Mechanical Engineers, Mr. E. B. Rosa, Chief Physicist, U. S. Bureau of Standards, gave some results of a careful study of the various activities of the scientific and engineering branches of the national government, and shows some very convincing figures relating to the economic value of these various activities. An abstract of his paper follows:

In order to get a more accurate knowledge of Government expenditures, and to ascertain how they have increased in recent years, the receipts and expenditures of all departments for the past 10 years were analyzed, using the official published records of the Treasury Department for the purpose, but following a somewhat different and more detailed classification. Appropriation bills do not show the earnings or credits to bureaus and departments and hence in many cases are misleading as to the real cost of a given branch of the service. In some cases the whole cost, and in other cases a large part of the cost, is covered by fees or earnings. Examples are the Consular Service, the Patent Office, the Land Office, the Reclamation Service, the Bureau of Navigation, the Forest Service, National Bank examinations, the Federal Reserve Board and notably the Post Office. A "billion dollar Congress" was a familiar phrase in pre-war days, but this did not mean that the National Government cost the taxpayers a billion dollars a year. It meant merely that the gross annual disbursements of the Government, including the entire business of the Post Office Department, amounted to a billion dollars per annum. In no single year prior to our entry into the great war were the net expenses of the Government as much as $700,000,000. The important distinction between gross disbursements and net expenses is too obvious perhaps to be emphasized, but it is often overlooked. This study has yielded results of very great interest and value, and throws much light on the question of the cost of government, and whether the civil side of the Federal Government is overdeveloped, and to what extent it is a burden upon the taxpayer.

The Classification Adopted.—In order to obtain the relation between the scientific and engineering work of the Government and other Government activities, both as to distribution and expenditures, we may review briefly the organization of the Government, which for the present purpose may be divided into two parts, the civil and the non-civil. The civil side of the Government may be divided into three groups of departments or activities as follows:

I Primary Governmental Functions
II Research, Educational, and Developmental Work
III Public Works (New Construction).

The remaining activities may be grouped as follows:

IV Army and Navy
V Pensions and Care of Soldiers
VI Obligations Arising from the Recent War
VII Interest
VIII Public Debt, Loans, and Trust Funds.

Lastly, Group IX includes all revenues of the Government which are derived from direct or indirect taxation.

Scientific and Engineering Work of Government.—The members of the engineering profession are especially interested in the constructive activities, all included in Groups II and III. Figures 2 and 3 have accordingly been prepared to show in detail the nature of the work and wide range of scientific and industrial research and engineering construction Gross disbursements, receipts and net expenses are shown on these charts. While Fig. 2 is based on the average for the fiscal years 1910 to 1919, Fig. 3 shows the aggregate expenditures and earnings during the entire period, together with the relative amount for each year.

The 15 bureaus of the Agricultural Department constitute the first half of Group II. This work is of fundamental importance not only to farmers and agricultural communities but to the entire population, for an abundant supply of food is essential to the welfare and even existence of the nation and as the urban population increases more rapidly than the rural, the food problem becomes more serious. The total cost of these investigations is not one-tenth of 1 per cent of the value of the agricultural products produced, and there can be no question that the value of the work done far exceeds its cost.

The Geological Survey is one of the oldest of our scientific bureaus and has done notable work of the greatest scientific and economic value. It includes, besides structural and economic geology, topographic surveys and studies of water supply and water power. The Bureau of Mines is an outgrowth of the Geological Survey, and is concerned with all the problems of mining and quarrying and the handling and treatment of their products, and also many phases of the petroleum and natural-gas industry, and the use of fuels. These materials are fundamental to the industries, and work which helps the production of fuels and such important raw materials as metals and minerals is of prime importance.

The Bureau of Education has done important and useful work, but has never been developed on a scale commensurate with the importance of its field. It is believed by many that the Bureau of Education should take a leading part in studying the science of education, and co-operate effectively with the educational institutions of the country in setting standards of education. It would not and could not dominate or control education, and there would be no danger of such a result. But it should be able to co-operate effectively and worthily, and to assist in raising educational standards where they are too low. The Federal Government is now assisting the states to the extent of $100,000,000 a year in the building of highways. Why should it not assist in the supremely important work of education by taking a leading part in studying the problems of education?

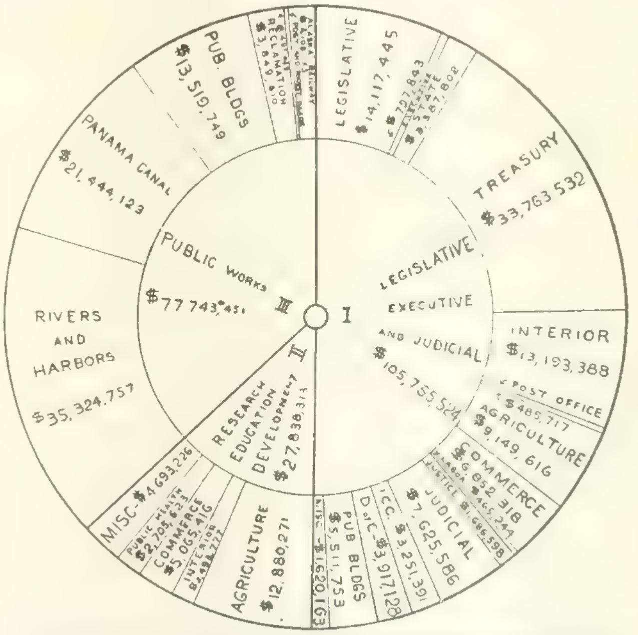


Fig. 1—Average Annual Net Expenditure of Federal Government During the Period 1910 to 1919 for Groups I. II and III—Civil Activities, $211,337,288.

Four bureaus of the Department of Commerce are included in Group II. The Coast and Geodetic Survey does fundamental work upon which all other surveys are based, and also does the valuable work of charting the coasts and locating obstructions to navigation. The Bureau of Standards maintains the fundamental standards of physical measurement. It co-operates with foreign governmental institutions in maintaining international uniformity in such measurements. It provides or calibrates copies of standards for states and manufacturers so as to insure uniformity in physical measurements. It develops instruments and methods to secure the highest possible accuracy in measurement and the greatest permanence and reliability in standards. It co-operates with engineering and trade organizations in standardization work, and carries out investigations on the properties of materials to secure data for such standardization. It furnishes information to the various branches of the Federal Government, to state commissions and officers of state and municipal governments, and to the industries of the country and the general public.

Much other valuable work of an educational and developmental character is shown on the Group II chart. The aver-the cost of all this work for the [illegible] 28 ct. a year per capita of the country's population [illegible] a very small sum in proportion to the importance of the interests represented, and also in proportion to the aggregate of the Federal taxes collected.

Public Works—New Construction.—The Panama Canal was opened to navigation in 1914. Its total cost for construction and equipment to date is $367,000,000. During the past six years its revenues have amounted to about $34,000,000 and its expenditures for operation and maintenance to $36,000,000, a net deficit of $2,000,000 for the entire period. Had it not been for the slides in 1916 which closed the canal for seven months and greatly reduced the revenue that year, there would have been a surplus of $2,000,000 for the entire period instead of a deficit. The surplus in the fiscal year 1920 amounted to more than $2,000,000, and this should increase year by year. More than $210,000,000 out of the total cost of $367,000,000 was provided out of current revenues of the Government from 1910 to 1915, and hence was included in the $2.15 per capita of civil governmental cost during these years. This is one of the engineering triumphs of the present century, and is another illustration of the successful handling of large public undertakings by the people co-operatively; that is, by the Government.

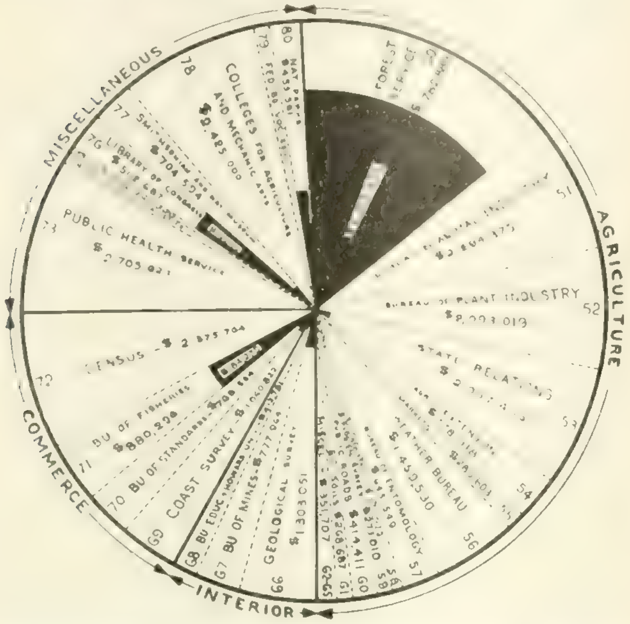


Fig. 2—Average Annual Expenditures and Earnings From 1910 to 1919 for Group II—Research, Education and Development.

Total area of each sector represents gross disbursement; black area represents receipts; white area represents net expenditure.

Another large undertaking of an engineering character is the river and harbor improvements, carried out by the engineers of the army but charged in this study to Public Works. During the 10 years, 1910 to 1919, inclusive, more than $350,000,000 was expended in this very important work. From Hell Gate to the Golden Gate, and from Duluth to the delta of the Mississippi, this work has been carried on for many years and is of great aggregate importance.

A third important item in this group is the construction of new public buildings, and during the 10-year period in question $135,197,494 was expended in the construction of postoffices, custom houses, hospitals and other Government buildings, about 120 new buildings per year being erected. The work is done by the office of the supervising architect of the Treasury Department, which for many years has handled this work. This also comes within the total of $2.15 per capita of civil governmental cost, about 79 ct. of which was expended in the public-works group. In addition to the construction of new buildings the supervising architect's office has charge of the operation and maintenance of 1,300 public buildings in all parts of the country.

The fourth item in this group is the construction of rural post roads, by co-operation with state highway departments. This work has been greatly expanded recently. During the 10 years, 1910 to 1919, inclusive, $4,970,489 was expended in the aggregate. But the appropriation for 1920 was $99,000,000, and for 1921, $104,000,000. This is more than the annual expenditure previous to 1920 for the entire range of engineering work included in Group III. The importance of good roads to the proper development of the country is now well understood, and there can be no doubt that the cooperation of the Federal Government will be to the advantage of the people as a whole. The building of roads is an engineering matter in which technical information and experience are of very great importance. The aid of the Federal Government not only stimulates and aids the states, which must pay at least half the cost, but tends to secure the best engineering service and to standardize road construction. It cannot fail to have a great educational influence upon engineers and road builders throughout the country, and to give the users of roads better roads and the taxpayers more for their money than if it is left to individual states. Moreover, in planning and building national highways it is very advantageous to have the Federal Government an active participant, in order to secure a better coordination of effort. As a measure of military precaution and preparedness the realization of a system of good roads on a national scale is of enormous advantage. As a help in getting food to market and supplies to farmers, it is of enormous economic value. As supplementing and in some cases supplanting railroads, such a system of highways is of great significance.

The fifth item is the Alaskan Railway, from Seward to Fairbanks. During the years 1913 to 1919, inclusive, $31,081,628 was expended on this important railway, which, when completed, will be 540 miles long. As with the Panama Canal, this is not an undertaking which private capital would care to undertake. But its ultimate success and its value in the development of Alaska can hardly be doubted.

The sixth item is the Reclamation Service, one of the most profitable and most interesting of the engineering projects of the Government. To reclaim the deserts and to create farms and homes and villages where before was waste and desolation is an inspiring undertaking; and to be able to create wealth far in excess of the cost of the work furnishes a double incentive. Since 1902 the Reclamation Service has constructed irrigation systems to supply 1,780,000 acres of land with water, and storage reservoirs sufficient to supply an additional million of acres. On this reclaimed land 40,000 families are living, and the population of the towns and villages within these projects had increased by as many more. It is estimated that the increased value of the land due to the work of the Reclamation Service is $200 per acre, or a total of more than $350,000,000. The annual value of the crops raised on these lands is estimated at $90,000,000. Most of the money expended on this work is derived from the sale of public lands and the money collected from settlers for the improvements made and the water service rendered

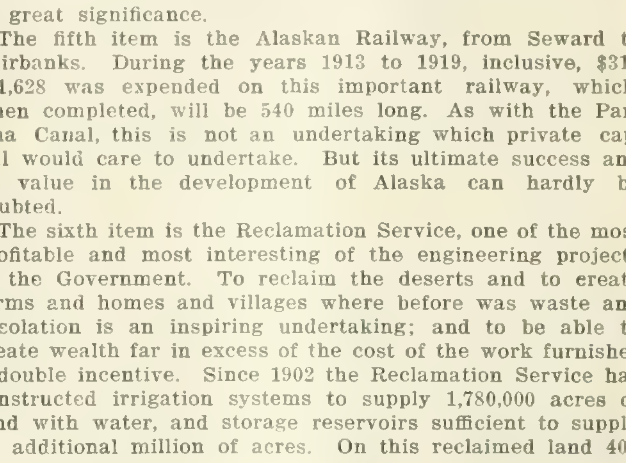


Fig. 3—Aggregate Expenditures and Earnings From 1910 to 1919 for Group III—Public Works.

Total area of each sector represents gross disbursement; black area represents receipts; white area represents net expenditure.

The Forest Service is akin to the Reclamation Service in that it is developing the public domain. It has been included in Group II, but may be mentioned in this connection. The national forests are located in 29 states in all parts of the country, although the larger portion is in the Far West. There are 152 different forest tracts, with a total area of 156,000,000 acres. The Forest Service has the responsibility of protecting and managing these vast tracts of land; studying how to develop the land best and make its resources most useful to the public. It yields a large revenue each year from timber cut (last year 800,000,000 board feet), and affords on its grazing ranges pasturage for 15,000,000 head of sheep, cattle, horses, goats, and swine. Watching the forests for the outbreak of fire, and fighting fires when they gain headway, is one of the important duties of the Forest Service. Another duty is applying scientific forestry to the development of the forests. Still another is studying the properties of woods and methods of treating and using woods. The Forest Products Laboratory of the Forest Service has done a great deal of valuable scientific and engineering work on a wide range of subjects. In planning its work and in developing the forests the Forest Service takes a long look ahead. Obviously, no commercial company could undertake such a work. The question of early dividends is not paramount with the Government. We have drawn lavishly, even recklessly in some cases, upon our natural resources, and it is well that we should be taking some thought for the future, and should be able to hand down to the next generation our public forest areas in better, rather than worse, condition than they are at present. The annual earnings of the Forest Service go a long way usually in paying expenses, and it is believed that in a few years they will pay the entire cost of the work, in addition to adding to their values year by year.

The Federal Power Commission is another agency doing engineering work akin to the Reclamation Service and Forest Service in that it is developing the natural resources of the country and indirectly creating wealth. It is different, however, in this important respect, that instead of carrying out engineering work itself, it has general supervision of power sites and their development and will grant permits to private agencies to carry out such work and supervise the carrying out of the work so that it shall not be inconsistent with the public interest. The power problem is a very fundamental one, and the recent unfortunate experience of the industries and public utilities which depend upon coal emphasizes the need for the Government to do what it can to make the water powers of the country available to the industries. It is to be hoped that the Federal Power Commission will be given such means to work with that it will be enabled to attack the problems before it effectively and successfully.

All these important constructive activities of the Government (as shown in Fig. 3) were carried on for the 10-year period at a total cost of $77,000,000 and an annual cost of about 79 ct. per capita of the country's population. That so much could be done at so slight a burden to each is of course because it is shared by so many. And this is the principal argument in much that the Federal Government does, particularly in research and development work. To do it once well and place the results at the disposal of all is far cheaper as well as better than for separate agencies to do it many times.

Efficiency in the Government Service.—How to increase efficiency in the Government Service is an important question, and nobody is more interested in it than those in the service. The problem is not merely how to reduce expenses, or how to get a cheaper government; but rather how to get the maximum of service and the best government possible for a given expenditure. The Government is a great cooperative undertaking for the benefit of all the citizens of the United States. Obviously, ability, integrity, and experience are essential in those who conduct the various branches of the Government. The personnel must not change so frequently that a large proportion of the employes are merely learners, but should be so stable and competent that efficient service can be given.

It has been shown that the cost of all the civil activities of the Government during the 10 years from July 1, 1909, to July 1, 1919, averaged $2.15 per year per capita for the population of the country, and that during this period the cost increased barely as rapidly as the population of the country increased. At the same time the cost of commodities more than doubled, the cost of living doubled, and the cost of doing private business increased in proportion. Put in other terms, the per capita cost of the civil side of the Federal Government in 1920 was only a little more than half of what it was in 1910 if measured in commodities or in money of equal purchasing power.

During this 10-year period the wealth of the country had greatly expanded, the war had come and gone, the problems of government had greatly increased, and yet the per capita cost of these civil activities measured in commodities had fallen to a little more than one-half. In the face of these facts, people are saying that the Government is extravagant, inefficient and overdeveloped. Would it not be fairer and within the truth to say that the civil side of the Government taken as a whole is not subject to such unqualified statements. To be sure, there is inefficiency and incapacity; because salaries in many grades are inadequate, the turnover in the personnel has been excessive. This has tended to make the service in many cases inefficient and unsatisfactory. Too large a proportion of the personnel is inexperienced; too many are learners, and too few thoroughly competent.

In some branches salaries are higher than the average and conditions are more favorable; and if at an early date the salary scale can be standardized and appreciably raised (especially where it is below the average), there is good reason to believe that conditions can be greatly improved. Given favorable conditions as to salaries, and an even chance with private business in other respects, it seems safe to expect that an enormous improvement would follow, and that the executive departments of the Government would obtain results both creditable and gratifying. Under such conditions plenty of able men can be found to work for the Government, in many cases at less salaries than the industries pay. And they would be productive and efficient and their work useful and profitable to their employers, namely, the people of the United States. It would be stimulating and inspiring to serve the Government under such conditions. Let us hope that measures under consideration may go far toward realizing these improved conditions, and that the scientific and engineering work of the Government may soon be on a thoroughly stable and satisfactory basis.

Why the Government Does Scientific and Enginering Work.—The first reason for the Government's doing research work in science and engineering is for the sake of science itself and its application, to promote knowledge and advance our civilization. Research in pure science and its manifold applications is carried on by many agencies. Municipal and state institutions, industrial or endowed laboratories and individuals at their own expense are constantly carrying on and publishing scientific research. For a thousand years governments have taken a leading part in the promotion of learning, and in more recent times in scientific and industrial research. History shows that scientific research justifies itself, and the United States of all countries in the world at the present time should take a forward step in this matter. At the present time and for years to come, scientific research, and the cultivation of learning in the countries of Europe cannot be what they were before the war. The enormous national debts of those countries, the depreciation of their currency, the increased cost of living, in many countries, the demoralization of industry and in some countries the continuation of war, all tend to retard the resumption of intellectual pursuits and the cultivation of science and learning. Since the war the national budget has greatly increased and the need for scientific and educational work has also greatly increased. We cannot draw upon other countries in future to the extent we have in the past for the results of scientific research. Are we going to recognize and meet the obligation resting upon us as a nation?

The second reason for research is to aid in making Government efficient and effective through providing as complete knowledge as possible concerning the problems encountered in the administration of the Government, such as those involved in constructing public buildings and other public works, in making public contracts, in inspecting and accepting deliveries on contracts and in collecting the revenue. In all phases of government it is important to have full and reliable technical information. In view of the large interests at stake, and the supreme importance of having the Government maintain a high standard of intelligence, integrity and justice in its dealings with its own people and others, it seems indisputable that generous expenditures made for scientific research for the purpose of aiding the Government itself would be justified.

The third reason for such research is to benefit industry, to raise the standards of business practice, to increase efficiency, to reduce waste, and to create wealth. Hundreds of corporations, large and small, maintain research laboratories for the development of their business, and there is no suggestion here that these be discontinued. On the contrary, they will become more efficient and more useful if the Government carries on a large amount of fundamental research work designed to assist them and to make their work more useful and more reliable. It is better and cheaper to have fundamental work done once thoroughly than many times imperfectly. Hence if the Government does a large amount of research work of value to the hundreds of industries that require such information, it will enable them to do their work better and the public that pays all the costs to be better served.

There are many subjects of research in which the industries, through engineering societies and trade organizations, co-operate in carrying out experimental or statistical investigations. There is a great advantage in such cases in having the Federal Government co-operate, to be one of the group carrying out a given investigation, and if possible one of the most active. In many cases antagonistic interests can be harmonized and co-operation promoted by the presence of the Government. Unfortunately the Government agency most concerned is sometimes unable to respond to such invitations for lack of money. Such work must all be paid for in the end by the general public whether it is all done by the business corporations or some is done by the Government. If the Government participates (in a competent manner, of course), the work will be benefited, the results are more likely to be available to all the interests concerned, and the Government is often able to exert a helpful influence on the industry. Examples could be cited over and over again where this has resulted. Such work is constructive and helpful, and often more valuable in improving commercial practice than the more drastic methods sometimes employed by the Government. Such work by the Government if done adequately would be of enormous value in developing industry and making it better able to compete with other nations. We hear proposals to increase the tariff to give our manufacturers an advantage in our own markets. At the same time we are spending vast sums to build up a merchant marine to carry our products to the markets of the world. We should not therefore forget to do something in a constructive way to help the industries of the country, to increase their efficiency, to reduce waste and costs, to develop new processes and to compete as to quality and cost with the world. Thus will commerce be developed and cargoes provided for our shipping, without which the latter is useless.

The fourth reason for such research is to furnish reliable information on technical, social and economic subjects in order to aid in securing an intelligent public opinion. Many injustices to society are prevented or corrected by the force of public opinion without legislation or governmental action. But in order that it shall be an effective and healthful influence it should be an enlightened public opinion. It should be based upon reliable information, scientific, engineering, social or economic. For a government to mislead its people by the dissemination of false information is criminal; to needlessly leave them in ignorance by failing to tell the truth, or failing to secure information that would be of great economic and social value, is unfortunate, to say the least. Education and an enlightened public opinion are essential to the success of a democracy, and much greater attention to science in its broadest sense and to the application of science and the diffusion of knowledge would be of vast assistance in securing such an enlightened public opinion.

The fifth reason for such work is for the purpose of developing the natural resources of the country and the national domain. The Reclamation Service, the Forest Service, the Geological Survey, and other bureaus (and just now the Federal Power Commission) are doing work of this kind of great economic value. It is important to discover new supplies of oil or gas or coal or other minerals, to reforest our exhausted timber lands, and to utilize our water powers. It is of equal importance to discover methods of economizing in the use of oil and gas and coal and timber, or of securing by co-operation and education the use of methods already well known. The needless destruction by fire of buildings, the unnecessary consumption of fuel in engines and boilers, the waste of power and of materials which tends to deplete our natural resources, should be studied thoroughly by the Government. Private agencies as a rule are not in position to solve such problems. The Government can afford to take a long look ahead. When 100,000,000 people co-operate in a national problem, the cost upon each is very little and the chances of securing the needed co-operation are vastly increased. Such work pays abundantly in the early future if not in the immediate present, and it will pay again in the more distant future. While using up or destroying our inheritance from the past we should not be unmindful of those who come after us.

The sixth and final reason for the Government's doing scientific and engineering work on a generous scale is to increase the efficiency of the army and navy, and to make more effective the preparation of the nation for military effort in the future. Modern warfare is largely a matter of the application of science and engineering to production, transportation, and destruction, all on a gigantic scale. Including the selection, training, feeding and care of men, the development of armament, methods of defensive and offensive warfare, communication and signaling, operations on sea and land, under water and in the air, there is present an infinity of problems, first, for keeping up with the progress in all lines of scientific achievement, and second, for making advances and inventions beyond the limits of what is already known. When one considers how vast is the field of modern military and naval activity he can appreciate how useful to the military departments is the scientific work done by the civil establishments if done adequately and well. During the war almost every scientific laboratory in the country was engaged upon military problems. Many worked inefficiently, or to no purpose, but all made serious endeavors and many succeeded. If the lessons of the war are not to be lost, we shall be better prepared next time, and one of the most effective means of insuring that end will be to develop the scientific resources of the Government. If the development of scientific methods and the applications of science are not made in time of peace it will be vastly more costly, if not indeed too late, to do it after war begins. In time of peace such knowledge will promote efficiency, reduce waste and useless experiments and pay for its cost many fold. The military value of a greatly augmented scientific program would abundantly justify its cost, but the same work would in most cases be worth quite as much to the civil interests of the country.

Welded Pontoons for Supporting Dredge Discharge Pipe Lines

In reclamation work where pontoons are used as supports for dredge discharge pipe lines extending over water surfaces, a welded steel pontoon has given good service. An interesting example of the use of welded pontoons for work of this kind was afforded when a large Chicago dredge and dock company undertook a reclamation contract in the Great Lakes region some time ago. On this project, for which large "sand suckers" were used, it was necessary to carry a 24-in. discharge pipe across water from the pumps to the fill, and arrangements were made with the Oxweld Acetylene Co. to fabricate 95 steel shell pontoons, each 34 in. in diameter by 45 ft. in length.

The material used was 5/16-in. soft annealed steel sheets, cut and rolled to make a tube of the required diameter and 15 ft. in length. The edges were carefully matched, clamped and then welded together, the operator starting the weld at one end and continuing until the entire 15-ft. section had been welded. One man working eight hours averaged 45 ft. of welding.

The pontoons were assembled by welding three of the 15-ft. sections end to end and welding in dished end plates. In each 15-ft. section a 15-in. hole was cut and a manhole flange welded on. When completed the pontoons were filled with air at 60-lb. pressure and floated. The seams proved in all instances to be watertight, a property they retained throughout their service.

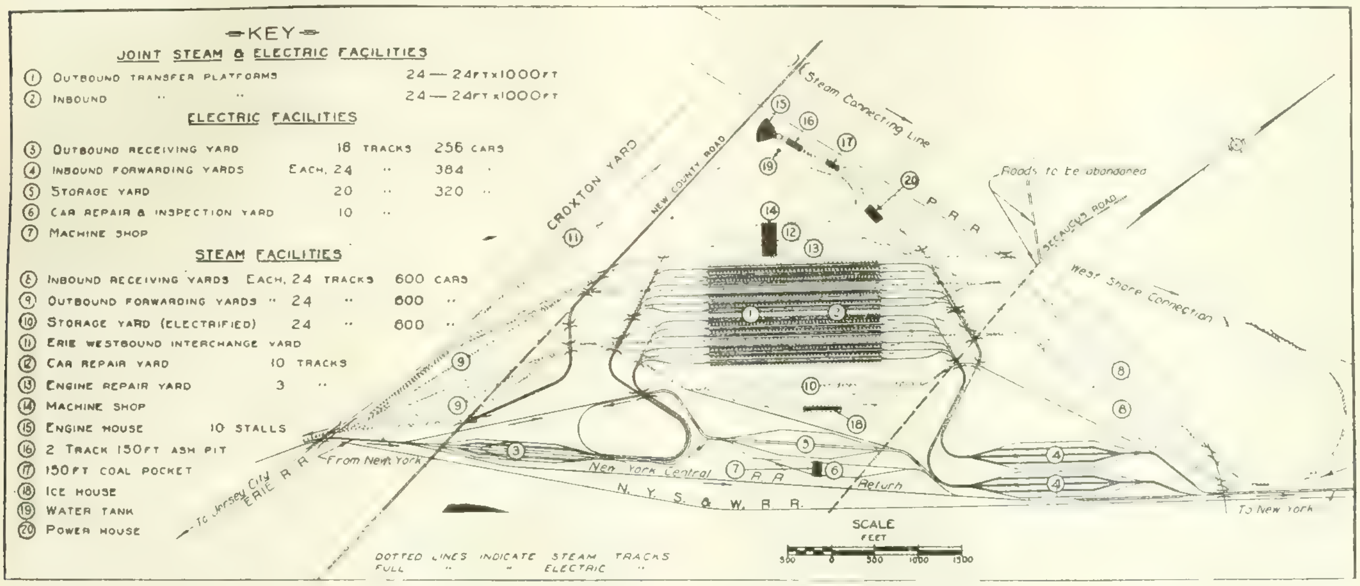
An Automatic Terminal Railway for New York

In December, 1920, the New York, New Jersey Port and Harbor Development Commission presented to the governors of the two states its report, comprehensive plan, and recommendations respecting present and prospective conditions at ports and terminals in the vicinity of New York City, and means for most effectively providing for the future.

General George W. Goethals was consulting engineer for the commission; B. F. Cresson, Jr., was chief engineer; W. W. Drinker, terminal engineer; J. E. Ramsey, chief statistician; and C. W. Stark, engineering editor.

Among the many interesting and instructive features of the report one of the most novel is the proposal of automatic electric operation of freight trains in the terminal system; and we herewith present an abstract treating of the terminal and track systems and their operation. Our abstract is taken largely from the summary which constitutes Part I of the report. In all, some 40 pages are devoted to the subject of the automatic railway.

A Saving in Terminal Costs.—The commission has evolved a plan which will release the Hudson River waterfront from pier-station occupancy, will afford some relief to the New Jersey waterfront, will dispose of the New York Central's surface tracks, will provide ample capacity for the future and will still effect a large saving in terminal costs. Furthermore, the plan lends itself to expansion as does no other one suggested. It can be made to serve all Manhattan and connect with the New York, New Haven & Hartford and Long Island railroads as well as the other railroads of the port.


KEY
JOINT STEAM & ELECTRIC FACILITIES
① Outbound transfer platforms 24—24ft x 1000ft
② Inbound " " 24—24ft x 1000ft
ELECTRIC FACILITIES
③ Outbound receiving yard 18 tracks 256 cars
④ Inbound forwarding yards Each, 24 " 384 "
⑤ Storage yard 20 " 320 "
⑥ Car repair & inspection yard 10 "
⑦ Machine shop
STEAM FACILITIES
⑧ Inbound receiving yards Each, 24 tracks 600 cars
⑨ Outbound forwarding yards " 24 " 600 "
⑩ Storage yard (electrified) 24 " 600 "
⑪ Erie westbound interchange yard
⑫ Car repair yard 10 tracks
⑬ Engine repair yard 3 "
⑭ Machine shop
⑮ Engine house 10 stalls
⑯ 2 Track 150ft ash pit
⑰ 150ft coal pocket
⑱ Ice house
⑲ Water tank
⑳ Power house
Croxton Yard
New County Road
Steam Connecting Line
P. R. R.
Roads to be abandoned
Secaucus Road
West Shore Connection
To Jersey City Erie R. R.
From New York
New York Central R. R.
Return
N. Y. S. & W. R. R.
To New York
SCALE FEET
500 0 500 1000 1500
DOTTED LINES INDICATE STEAM TRACKS
FULL " " ELECTRIC "

General Plan of Steam and Electric Yard in New Jersey for Joint Use of New Jersey Railroads and Automatic-Electric System.

The plan is based on the general principle of a moving platform or continuous conveyor placed underground away from conflict with either surface traffic or subsurface transit lines. The system will resemble a railroad in appearance, but will function more as a conveyor, electric circuits instead of visible mechanisms holding the cars and trains in virtually fixed positions with respect to each other.

The Essential Elements.—A belt-line railroad in New Jersey reaching all of the New Jersey railroads that give pier-station service; a joint yard and transfer station on the belt line; two parallel but independent tracks of standard gage, running in a loop, mainly in separate tunnels, from the yard to Manhattan and back to the yard; a series of multiple-story terminals over the loop in Manhattan, with car elevators from the surface to underground siding tracks; a separate connection and transfer station in Manhattan for the New York Central Railroad; a fleet of special electrically operated cars, and a fleet of small four-wheel trailer trucks.

Inbound freight will be transferred at the joint transfer station to trailer trucks, which will be borne by the electrically operated cars, mainly in eight-car trains, to the Manhattan stations. The trains will be despatched as nearly as possible at uniform intervals and run at uniform rates of speed not exceeding 14 miles per hour, making it safe to move the trains at short intervals. At the stations the cars will be raised to the surface one at a time and their loads exchanged for trailers bearing outbound freight, after which they will be despatched in eight-car trains to the transfer station and unloaded into standard freight cars. The electric cars will move around the loop on either track in one direction only, each loop thus forming an independent line.

Train Control by Despatcher.—An important economic feature of this system is its automatic operation, as it is proposed that the electric trains shall be run between the joint railroad yards and the terminal stations in Manhattan without train operators, the trains being electrically controlled by the train despatcher and his assistants on the line. In this way there is substituted mechanical precision for the human fallibility of manual control. The system can be operated by either alternating or direct current, although alternating current seems to be the more advantageous.

A similar installation on a smaller scale is being made by the Post Office Department of the British Government in London. That department began a series of tests ten years ago and before the war interrupted the work had completed 6¾ miles of deep tunnel of 9-ft. diameter between the outlying railway stations and the General Post Office in the center of London. The electrical equipment for this system is now being purchased. As a result of these experiments it is planned to run and brake this system entirely automatically with speeds up to 35 miles per hour. An automatic interlocking block-signal system will be used with trailing dead sections of track.

The Ideal System.—The commission's analysis of the automatic-electric plan it has developed includes estimates of construction and operating costs and of capacity. The results are so favorable that the commission recommends its adoption, considering it to be the ideal system for general merchandise distribution for Manhattan. The body which is entrusted to finance and build the system should, of course, go farther into the many details of its design, which are not here covered, and make any necessary practical tests.

Other parts of the port, which already enjoy direct rail service or can be provided with it, have at present no need for automatic-electric service, which Manhattan requires to release its waterfront in railroad use and to reduce the cost of handling its large volume of general merchandise freight. The automatic-electric principle, however, is applicable throughout the port, wherever the congestion and volume of package freight reaches sufficient proportions to call for an auxiliary to the direct rail service.

The Proposed Route.—In the initial development it is proposed to link up the New Jersey railroads by a belt line along the eastern margin of the Hackensack Meadows and build a joint railroad yard in New Jersey east of the Croxton yard of the Erie Railroad. The automatic-electric tracks will start from this joint yard in New Jersey, pass under Bergen Hill and the Hudson river to a point in Manhattan at about Forty-

[illegible]th street, thence turn southerly [illegible] certain streets suitable for the location of convenient terminals, turning back to the joint yard via another set of tunnels in the vicinity of Battery Place. For estimating purposes a definite route has been selected which would serve most of the Manhattan section some distance back from the Hudson river waterfront. The exact location should not be adopted without further study by the authority charged with the duty of building the system.

Extra Deep Subways.—The location of the system far below the surface in Manhattan will make it possible to construct it by tunneling methods rather than by the expensive cut-and-cover methods of work nearer the surface, with the necessity for underpinning abutting buildings and for maintaining existing sewers, water mains and other public utilities and conduits. It will also place the system entirely out of the way of the future rapid-transit construction Manhattan will require.

Cycles of Operation.—A consignment of freight for one of the Manhattan terminals, coming in a train with freight for other parts of the port district, will enter the existing break-up yard of the railroad company. Here the standard railroad cars will be classified as at present, and the car containing this shipment together with others containing other freight for Manhattan will be delivered to the public or private company operating the terminal system at the intersection of its belt line with the railroad company's line. The standard railroad cars will be hauled to the joint yard and placed in a receiving yard, whence they will be switched to tracks alongside the inbound ends of long transfer platforms.

Transfer Platforms.—Each of these platforms, twenty-four in number, will have a standard-equipment track on one side and an automatic-electric track on the other side. The freight will be unloaded from the standard railroad car upon trailers about 3 by 6 ft., and the trailers will then be hauled by tractors or by hand along the platform and placed upon one of the automatic-electric cars, which will hold twelve trailers. The standard railroad car will be pushed along the platform to the outbound end and reloaded with outgoing freight from other trucks, whence it will pass into an advance yard and be despatched to the railroad from which it came, or to any other railroad to which it is to be delivered.

Cars and Their Operation.—The consignment of freight will meanwhile have been loaded upon one of the special electric cars—a car somewhat larger than the ordinary box car, with a roof to protect its content, but roll sides to permit trailer trucks to be wheeled upon it at any point.

This car, controlled from alongside by a switch on the car within reach of an operator on the transfer platform or on the ground, will move from the platform at a low rate of speed (from 2.2 to 6.6 miles per hour) and be switched to a track assigned to the particular terminal to which the freight is destined, freight for only one terminal having been placed on the car. When sufficient automatic-electric cars have been accumulated, eight will be coupled together and despatched in a train. This train, with no other manual direction than the throwing of the track switch, will be accelerated to a speed of 1,200 ft. per min. (13.2 miles per hour) and take its place at not less than an established distance behind another train probably destined for a different terminal. The train will bear a distinctly visible indication of its destination, and when it reaches the entrance of its terminal an operator will throw a switch and divert it to a siding, where brakes will automatically be applied and it will come to a stop.

Terminal Elevators.—From this siding the automatic-electric cars will be run singly at slow speed upon an elevator. The elevator will raise the cars one at a time to an inbound platform at the street level and the cars will be run off under their own power. This platform will be the length of several cars, and each car will remain alongside the platform a minimum of twelve minutes, affording ample time for the wheeling off of the trailer trucks and the wheeling on of empty trucks. The consignment will be placed on the platform to be called for, as at the ordinary freight house, or removed to storage if the consignee fails to call for it within the free time limit.

The automatic-electric cars, having discharged their loads and received empty trailers, will be advanced one by one to a second elevator, which will lower them one floor to the outbound platform at the basement level. Here the cars, after having again at least twelve minutes in which to unload their empty trailers and receive loaded trailers with outbound freight, each car receiving freight for a single railroad, will proceed back to the original elevator shaft. The cars will then be run upon the first elevator and be lowered to the track level, this elevator having meanwhile made several trips and brought other cars to the inbound level.

Running off the elevator at the side-track level, the automatic-electric cars will be held until eight have accumulated, when they will be coupled and despatched as a train by exactly the same process as from the New Jersey yard, an interlocking signal system controlling the time when the train shall enter the main-line system.

Switching and Safety Devices.—Arriving at the joint yard, the train will be switched to one of the tracks of a receiving yard, where it will be brought to a stop automatically as before. Here the automatic-electric cars will be cut off one at a time, and started by an operator walking alongside, the cars moving at a speed of 2.2 miles per hour. They will proceed over a series of switches and crossovers, controlled from a central tower, by which they will be diverted to the proper tracks at the transfer station.

The cars will be stopped at the outbound ends of the transfer platforms. The loaded trailers will be removed and transferred to standard freight cars, other trailers previously emptied will be hauled by tractors along the platform to the inbound end of the platforms, the empty automatic-electric cars will be advanced to the inbound section of the transfer station to receive new loads, and the cycle will have been completed.

An important feature of the automatic-electric system is the contemplated trailing dead section of track, which will make it impossible for one train to come closer than a certain safe distance from the train preceding.

Non-Interference with Present Operations.—Inasmuch as the Manhattan terminals and main line of the proposed automatic-electric system are to be located inland from the waterfront, and the New Jersey belt line and joint yard will be on ground at present unoccupied in the Hackensack Meadows, the initial development of the automatic-electric system as outlined in the preceding paragraphs can be constructed, equipped and placed in operation without in any way hampering the operation of present facilities. The importance of this feature will be realized when it is considered that the estimated period required for the construction of this system under the most favorable circumstances is three years.

Certain other projects that have come before the commission would require tearing up existing tracks or abandoning certain piers to make way for the new construction. Such a procedure would greatly add to the existing congestion and produce a well-nigh intolerable state of affairs that would inevitably last for several years. Any attempt to construct a new system piecemeal on the site of existing facilities would greatly extend the construction period as well as increase the cost.

Manhattan Terminals.—Twelve Manhattan terminals will be required immediately. Five more, it is estimated, can subsequently be added before the terminal capacity reaches the capacity of the joint yard and main tracks.

Much depends upon the design of the terminals in Manhattan. The handling costs at the present pier stations have been found to be the largest single item of expense of railroad terminal operation, not to mention the enormous cost incident to truck delays resulting from congestion. These high handling costs are attributable to several causes, foremost of which are lack of platform space and congestion of drays. The commission has sought to avoid the same mistakes in its proposed inland terminals. Abundant driveway and platform space have been provided, inbound and outbound freight will be handled at different levels, and the arrangement of driveways is such that there will be no conflict of trucks coming to the terminal for different purposes, the traffic on certain of the adjacent streets being restricted to one-way operation.

To provide ample space for holding inbound freight awaiting consignees, and storage space as well for spare trailer trucks, it is proposed to build a floor above the inbound level as a part of each terminal. Above that it is proposed to build two additional stories for warehouse purposes, and it is estimated that the revenues that can be obtained from these additional floors will contribute materially to a reduction of the fixed charges against the system. Besides the two warehouse floors incorporated in the design, estimates have been made of the extra cost of and revenues obtainable from two additional floors per terminal for loft, manufacturing or office purposes.

It is proposed to provide two main tracks for the main system and an independent elevator and platform system for each main track at each terminal. At each terminal there will therefore be two car elevators that run the entire vertical distance between the deep-level tracks and the auxiliary terminal floor just above the street level, and two other shuttle car elevators that run between this floor and the outbound floor just below the street level.

Protection Against Tieups.—Assurance against complete suspension of service through accidents is important in a system such as the automatic-electric. This is provided in large measure by the division of the plant into two separate and parallel systems. There are two main tracks, each with its own tunnels, each with its half-terminals complete as to sidings, elevators and platforms. An accident to one elevator would merely incapacitate one twenty-fourth of the terminal facilities. Even a derailment on the main line would leave half of the plant in commission.

Character of Traffic to Be Handled.—Virtually all of the traffic now handled at the railroad pier stations and at the freight houses of the float-bridge terminals can be handled economically on the recommended system. The team-track and heavy freight of the float-bridge terminals cannot be accommodated, and these terminals should be retained.

Much freight not now handled at the pier stations can be taken care of admirably in the new system. This applies particularly to milk, and to other perishable food unloaded in New Jersey and trucked to New York. The suggested method of handling these commodities by the automatic-electric system is part of the commission's plan for improving the port's system of food distribution, and is set forth more fully elsewhere in the report.

The system is also well adapted to the handling of express packages. At present the express companies are poorly equipped in the way of terminals to serve the public in a satisfactory manner. An express station at each automatic-electric terminal will make for a much improved express service.

It is not essential that all freight carried by the automatic-electric system be carried on trailer trucks. These trucks will be convenient for most commodities to reduce rehandling. Shipments that will not go on the trailers can be loaded directly upon the automatic-electric cars, or placed in detachable motor-truck bodies which can be hauled through on the automatic-electric cars, and delivered at the terminals to motor-truck chassis which will take them to the store door.

Standard Cars Can Enter.—It will also be possible to bring a certain number of standard cars through the system and into the terminals. This practice will probably not be much resorted to, inasmuch as the bulk-breaking facilities at the transfer yards will be adapted to every commodity the system can handle.

Automatic System Is Economic in Both First Cost and Operation.—With twelve Manhattan terminals the initial development of the automatic-electric system, normally operated ten hours a day, has an estimated capacity of 10,000,000 tons yearly, the tonnage expected in 1929. The estimated yearly capacity of the steam belt line, joint yard and Hudson river tunnels is 24,260,000 tons, and the capacity of the entire system can be brought to that figure by building five additional terminals. The capacity of the present facilities is indeterminate, but the congestion at times indicates that it is not in excess of the present peak loads. Table I compares the capacities of the recommended system and the present facilities, the capacity of the latter being assumed as that of the maximum short-period traffic found by the clockings sustained for a year.

The capacities of the elevated and subway systems for standard equipment are also shown for comparison. They, moreover, are based on operation for 24-hour days.

Table II shows for comparison the estimated costs of construction and equipment, ready to operate, of the automatic-electric, the standard equipment elevated and the standard-equipment underground systems. The automatic-electric figure covers twelve Manhattan terminals, which will give an estimated capacity of 10,000,000 tons. All three figures are based on 1918 prices, which the commission deems as nearly normal for the future as can be obtained. In this and the succeeding tables the interest rate for money borrowed for construction is assumed at 5 per cent. Amortization of the entire investment in fifty years is provided in all of the automatic-electric estimates that follow, but not in those for the other systems.

Table III shows the estimated cost per ton of operating each plant, and the costs at those rates for moving 10,000,000 tons of freight per year. The automatic-electric system alone has a 10,000,000-ton capacity, but to show the other systems as favorably as possible this fact is disregarded, expanding them to the desired capacity would require much new construction, entailing additional fixed charges that would undoubtedly keep the unit costs of operation, which include both direct costs and fixed charges, at least up to the figures recorded.

Thus the advantage of the automatic-electric system over either standard-equipment system is overwhelming in capacity and cost of operation, with less capital investment, and consequently the standard-equipment system can be excluded from further consideration.

Return on Investment.—The advantage of the automatic-electric system over present methods is marked as to both capacity and cost. The increased capacity alone would not justify the new system, but the difference of 43 cents per ton in operating costs means that the system will pay 5 per cent on the investment and save 19 per cent of the present cost of the terminal operations covered in the railroad rate.

This is not, however, the only saving possible through the automatic-electric system. It is but one of fourteen items listed in Table IV, in every one of which the public is directly or indirectly concerned.

Item 1 is that indicated in Table III, amounting to about 43 cents per ton or $4,318,000 on 10,000,000 tons. It includes (a) the direct advantage of the automatic-electric system over present facilities in the sum of direct costs, fixed charges and credits from two revenue-producing warehouse floors in each terminal; (b) the estimated value of an average saving of two days in the cycle at the port of the railroad cars handling the freight, and (c) the estimated saving through material reduction in the movement of empty cars. (At present approximately 25 per cent of the cars in Manhattan pier-station service move empty one way.)

Items 2 and 3 are direct public benefits arising from eliminating congestion and consequent idle time of trucks at stations, and from making every station a receiving and delivery point for every railroad using the system.

The sum of items 1, 2 and 3 represents a saving to the community of $7,120,000 per year, or a net return on capital

TABLE I—ESTIMATED MAXIMUM CAPACITY.

	Tons of freight per year	
Automatic-electric system	14,260,000	
Present car float-pier station system	8,000,000	
Added capacity	6,260,000	77.8%
Standard-equipment elevated system	6,115,000	
Standard-equipment underground system	6,115,000	

TABLE II—ESTIMATED COST OF CONSTRUCTION AND EQUIPMENT AT 1918 PRICES.

Automatic-electric system	$201,190,000
Standard-equipment elevated system	241,131,000
Standard-equipment underground system	255,009,000

TABLE III—ESTIMATED COST OF MOVING 10,000,000 TONS OF FREIGHT FROM BREAK-UP YARDS TO MANHATTAN STATIONS AT 1918 PRICES.

	Per ton.	Ten million tons.
Present car float-pier station system	$2.25	$22,500,000
Automatic-electric system	1.82	18,200,000
Saving, automatic-electric system	$0.43	$ 4,300,000
Standard-equipment elevated system	$3.47	$34,700,000
Standard-equipment underground system	3.66	36,600,000

TABLE IV.—SAVING BY AUTOMATIC-ELECTRIC SYSTEM ON BASIS OF 10,000,000 TONS HANDLED ANNUALLY.

1. Saving over present system in railroad operation	$ 4,318,000
2. Saving in truck delays	1,648,000
3. Saving in trucking distances	1,154,000
Total	$ 7,120,000
Per cent above 5 per cent interest on $201,190,000	3.54%
4. Net rentals from two additional loft floors	6,416,000
Total saving	13,838,000
Per cent above 5 per cent interest on $218,630,000	6.22%

Important Items of Saving Impracticable to Estimate Accurately.

5. Increased average loading of railroad cars.
6. Increased average loading of trucks.
7. Saving to public through quicker terminal movement.
8. Reduction in trucking expense to tenants of terminal buildings.
9. Reduction of trucking of milk, produce and live poultry from New Jersey.
10. Inherent possibilities of saving in spoiling of food.
11. Decreased maintenance in city streets.
12. Freedom from interruption by fog and ice.
13. Increased real estate values.
14. Increased commercial capacity of all Manhattan.

investment required of 3.54 per cent in excess of the interest and amortization charges. This saving [illegible] percentage of return can nearly be doubled (item 4) by [illegible] and renting two additional loft floors in each terminal, the cost of which will be only $17,440,000. This will increase the total calculable saving to $13,838,000 per year, or a net return on the capital investment of 6.22 per cent over the assumed fixed charges.

Unmeasured Benefits.—Items 5 to 14 are difficult to estimate but none the less important. The average load per car in the Manhattan general-freight service will undoubtedly increase when it becomes possible to consolidate loads for or from the joint yards. Establishing union stations in Manhattan will likewise probably make for consolidation of truck loads to and from the local merchant and manufacturer. Reducing the cycle of terminal operations will expedite the shipper's freight and help his business. Occupancy of lofts in terminal buildings will possibly entirely eliminate the trucking expenses of the tenants. Incorporation of the food-distribution changes the commission recommends with the automatic-electric system will render it unnecessary to truck milk, produce and live poultry to Manhattan as at present from the waterfront yards in New Jersey, and will by lessening the delays to and exposure of all kinds of perishable foodstuffs greatly reduce spoiling. All of these reductions in trucking, through reduced delays, reduced distances, increased loads and the substitution to a large extent of automatic-electric delivery, will have a marked effect on the wear and tear on our city streets, and the consequent maintenance costs. Freedom from interruption of railroad service by fog and ice will have its value. And finally, the generally improved conditions will make Manhattan and the entire port a more desirable place in which to do business, will give it a greater capacity for doing business and will have a generally beneficial effect on real estate values.

These specific items of saving attaching to the automatic-electric system itself merge into other public benefits made possible by the system, some of which perhaps have no money value, but all of which make for the convenience and comfort of the community. In this category is the adaptability of the system to voluntary store-door delivery and to the improved food-distribution system recommended by the commission. In it also is the release of waterfront on both sides of the Hudson river sorely needed for steamship terminals. All of these benefits are discussed at greater lengths later on in this report. They add to the many reasons why no one in the port district can regard the commission's proposal as of no concern to him.

Expansion of System.—The initial development of the automatic-electric system described in the foregoing paragraphs solves the West Side problem south of Fifty-ninth street and gives adequate relief where it is most necessary. It leaves to be provided for by expansion of the system the inclusion of the New York, New Haven & Hartford and the Long Island railroads and the removal of the New York Central tracks through Riverside Park. The comprehensive plan recommended by the commission meets both of these points by means of an additional loop in upper Manhattan connecting with the initial development and also with a second joint yard on the East river to serve the three New York railroads. While the commission believes that Ward's and Randall's Islands might best eventually become public parks and that suitable locations for such a yard may be found in that vicinity by the port authority on the Bronx or Queens shores, the commission's map, merely for purposes of illustration, shows such a typical yard on the city's property rather than on private property.

Electric Fundamentals of System.—The basic electrical features of the system are the provision of (1) operation at moderate speed of the trans between the yards and the terminals, (2) low-speed man-controlled operation in the yards and in the terminals, and (3) means of effecting the transition from one form of operation to the other.

The first requisite involved the determination of a speed sufficient to move the freight in a reasonable time the several miles between yards and terminals, and the provision of "trailing dead sections" behind each train to eliminate the possibility of collision. The speed adopted as satisfactory from the viewpoint of despatch in moving the freight and also from that of the electric characteristics is 1,200 ft. per min. or about 13.6 miles per hour. This speed compares favorably with that of the average freight train, and will bring a car from yard to terminal in from 15 to 30 minutes. The trailing dead section is explained on page 271.

For the low speed 200 ft. per min. or about 2.27 miles per hour was adopted as slow enough to permit men to start and stop the cars from the ground or platform without mounting the cars, and to minimize the damage from collision without choking the system.

Transition between the higher-speed automatic movement of the cars in trains and the low-speed manually controlled movement of single cars will be accomplished by means of special accelerating and retarding or decelerating sections of track about one and one-half train lengths long, such tracks to be side tracks connected with the main tracks. The throwing of a switch will start a train on an accelerating track and it will automatically speed up to 1,200 ft. per min. before leaving the section and entering the main track. When it arrives at one of the yards or the terminal for which it is intended the throwing of a switch will turn it from the main track, and it will be automatically brought to a stand-still on a decelerating section after it has cleared the main track. At the same time the individual cars of these trains can be operated at will under manual control at the low speed anywhere on the accelerating or decelerating section.

On the basis of these three fundamental electrical requirements, it was determined that there should be two main tracks throughout the system, the two operating in the same direction and forming two parallel loops. Each main track will have its independent connection with each terminal. Under peak-load conditions there would theoretically be a train on each track every 3.29 min., assuming that the system would operate sixteen hours to accommodate such peak loads. In actual operation the minimum spacing will be less than this because of the necessity for operating the New Jersey trains in fleets and inserting the New York Central trains between fleets, as is explained on pages 268-270.

Driveway and Tailboard Capacities.—To arrive at the driveway and tailboard capacities, some of the same assumptions were used as in the studies for the elevated and underground marginal railroads for standard equipment. It was assumed, for example, that the driveways would have sawtooth faces to permit trucks to back in readily without obstructing much of the driveways, and that the driveways alongside the platforms should be wide enough for four lines of moving trucks with trucks standing at the tailboard spaces. It was estimated as the result of a detailed study that through such a driveway in one of the subway terminals, where there would be no conflicting currents of traffic at the entrances and exits, 120 trucks per hour could pass, and the same figure has been used in this analysis, inasmuch as conflicting currents can also be avoided here.

Other assumptions similar to those previously used are truck loadings of two tons and one ton respectively for inbound and outbound freight, and a rate of loading or unloading at the tailboards of 12.5 min. per ton—these figures having been derived from the clockings made by the commission's field forces.

The terminals as laid out naturally vary somewhat to fit the street blocks on which they are placed, but the average or typical terminal has forty-eight tailboard spaces for trucks calling for inbound freight and thirty-six for trucks bringing outbound freight. Using these numbers and the other assumptions previously referred to, the hourly capacity of the twelve terminals, as far as the driveways and tailboard spaces are concerned, is 2,764.8 tons for inbound freight and 1,440 tons for outbound freight.

In the case of the inbound freight it is the tailboard capacity that governs, the result being derived by the product of the number of terminals, number of tailboard spaces per terminal, number of tons per truck and number of trucks that can load in one tailboard space in an hour, or $12 \times 48 \times 2 \times 60/25 = 2{,}764.8$. In the case of outbound freight it is not the tailboard capacity but the driveway capacity which controls, the figure being the product of the number of terminals, number of tracks per hour than can be moved through the driveways and number of tons per truck, or $12 \times 120 \times 1 = 1{,}440$.

Determination of the complementary capacity figures—driveway capacity inbound and tailboard capacity outbound—would show the former figure to be 2,880 tons (double the outbound because of double truck loads) and the latter to be 2,073.6 tons. The inbound driveway and tailboard capacities are nearly the same, showing little waste capacity. There is seemingly considerable disparity in the outbound capacities, but it is probable that the average outbound truck loads would be considerably increased under the improved conditions of the new terminals, in which case the disparity would be greatly reduced. Such a change would increase the driveway capacity without affecting the tailboard capacity, inasmuch as the calculations are based on the theory that there would be trucks at each tailboard space at all times, so that there could be continuous unloading, whether from one or more trucks.

Using the limiting capacities of 2,764.8 and 1,440 tons per hour inbound and outbound respectively, the twelve terminals, as far as the driveways and tailboard spaces are concerned, could handle 27,648 tons and 14,440 tons outbound in a 10-hour day, or 44,236.8 tons inbound and 23,040 tons outbound in a 16-hour day. When these figures are compared with the expected 1929 tonnages of 20,000, 13,333, 35,000 and 23,333 respectively, the desirability of increasing the outbound truck loads is apparent, and inasmuch as their average is so small in comparison with the physical capacity of the average truck, the commission deems it proper to take account of this in the design, and so avoid excess capacity for outbound freight.

At peak hours of peak days, as determined by tests at the railroad pier stations, the inbound freight increases about 34 per cent and the outbound 55 per cent. Overtime at the terminals will care for this, as there are only one or two peak hours, but it is thought that there is sufficient margin of safety in the hourly rate to take care of these by speeding up the operations.

Electrical Features.—The system can be operated by either direct or alternating current, but the latter seems better adapted and has been assumed in the estimates. If alternating current is used it will probably be generated and transmitted at 13,200 volts and stepped down at frequent substations to the voltages ranging from 550 down to 135 required in operation. The cars will receive their power through pantagraphs from two overhead trolley wires. Each car will be equipped either to run singly or to haul something more than its own weight in a train, so that one or two standard railroad cars can be made part of an 8-car train.

In order that the uniform speed necessary for the correct spacing of the various kinds of trains can be maintained, it is proposed to use squirrel-cage induction motors of moderately high torque, two to each automatic car. These motors will be so designed as to give good operating characteristics over a range of frequency of 60 cycles down to 10 cycles, the voltages being reduced in the correct proportions. On the main tracks, where a speed of 1,200 ft. per min. is to be maintained, the power will be supplied at 3-phase 60 cycles, 550 volts, while on sections where the desired speed is 200 or 600 ft. per min., the power will be supplied at correspondingly lower voltages and frequencies.

It will be necessary to distribute the power at high voltage and step it down to track voltage at short intervals in order to prevent excessive voltage drop in the trolley wires and tracks. Each car will have a simple reversing switch for its two motors, so that when on the low-speed sections of track an operator will be able to start, stop or reverse the car at any time. Each of the two motors will be provided with a delayed-action solenoid brake, so that when the power is shut off the car will coast a short distance before the brake takes hold and brings it to rest. This delayed action is necessary to allow the car to coast over dead sections of track which will be necessary at various points.

Movements of the cars singly at the 200-ft. speed will be accomplished by the simple process of having a man standing or walking alongside throw a switch on the car. The car will be under manual control at all times, but will not require a rider, and can be sent considerable distances from one operator to another.

Acceleration and Deceleration.—Acceleration and deceleration of the main-line eight-car train to and from the speed of 1,200 ft. per min. will be effected by means of a special section of track energized by a motor-generator set whose motor is of the variable-speed direct-current type—the motor-generator set being under the complete control of the chief train despatcher, but operating automatically as the switches are turned.

When the cars on the forwarding tracks are made up into eight-car trains, the current will be cut off from the track on which the train is standing and the switches of all eight cars will be closed in the forward direction. The chief despatcher by means of the motor-generator set will energize the track at 10 cycles, 135 volts, which will begin accelerating the train. The speed of the motor-generator set will automatically gradually raise the power supply to 60 cycles, 550 volts, which will bring the train to its full speed of 1,200 ft. per min. All of this will be accomplished at a rate of acceleration of 1 ft. per sec. or in a distance of 200 ft.

When the train has obtained its full speed it will run off the make-up track and enter the main track, when it will continue at this speed without further attention until it is switched into a decelerating section, while the motor-generator set will be released for use in accelerating the next train.

In the decelerating sections the process will be reversed, a variable-speed motor-generator set reducing the frequency from 60 cycles to 10 cycles and bringing the train to rest in 200 ft. after the deceleration is applied.

Where individual cars must be accelerated from a speed of 200 ft. per min. to one of 600 ft. per min. in the New Jersey yard, the headway is too short for a variable-speed motor-generator set; hence it is proposed to use sectionalized tracks with different frequencies on each section. For example, a yard man will despatch a car on a 10-cycle section by closing the car switch, and the car will automatically accelerate to 200 ft. per min. At the desired point it will enter a section of track energized at 30 cycles, and with the correct operating voltage for this frequency. This will accelerate it to approximately 600 ft. per min. Again, the car will enter another section energized to 10 cycles and 135 volts, and its speed will be automatically reduced to 200 ft. per min. All of this will be accomplished with no man control other than the original starting of the car.

Trailing Dead Sections.—Ordinarily the eight car trains, moving at a uniform speed varied only slightly by different conditions of load and grade, will maintain their proper spacing and be safe from collision. Provision must be made, however, for the protection of trains brought to a stop through derailment, burned-out motors or other causes. This provision is made by the use of trailing dead sections.

Throughout their length the main tracks will be divided into insulated sections of a train length plus the distance required to bring the train to a standstill from full speed. The electrical circuits will be so arranged that the current will be completely cut off from the second section behind each train, this dead section advancing as the train advances. If through any accident or error in despatching a train should come within the established distance of the train ahead, it will run upon this dead section and be stopped by the application of the brakes. When the train ahead gets far enough in advance, the dead section of track will automatically become energized and the train which has been stopped will be brought to speed again.

These dead sections, besides protecting trains stopped on the main line by accident, will prevent the despatching of a train from a terminal too close to the train ahead of it or behind it, the system in effect interlocking the forwarding tracks with the main tracks. If for any reason all trains are stopped, all will automatically start in the correct sequence and with safe spaces between them when the power is turned on again.

Trailing Light System.—Supplementing the trailing dead sections will be a trailing light system. In front of the chief despatcher's desk will be a large sectional map showing the entire main trackage of the system. As each train is despatched from any point on the system, a light will appear at that point on the map, and will follow the track in such a way as to show at all times the location of that train. If for any reason the train comes to a stop, the light will stop and will indicate to the chief despatcher that there is trouble at that particular point, since no trains are supposed to stop on the main track.

Elevating Grader Outfit Moves 1,350 Cu. Yd. of Earth Per Day.—In building a race track last summer at the Vicksburg, Miss., fair grounds an average of 1,350 cu. yd. of dirt was moved per 10-hour day by a tractor drawn Western elevating grader and 14 dump wagons. The high mark, according to The Earth Mover, was 1,500 cu. yd. The ground was a soft, boggy, spongy clay. The tractor was a 10-ton Holt Caterpillar. The length of the run was 500 ft.; width of the cut, 50 ft.; time to load was biven as 20 seconds; time to change wagons, 15 seconds; length of haul, 700 ft. W. C. Mullen was the contractor.

The Extent of Use of the Easement Curve

The following questionnaire was recently sent by the Railway Age to the Chief Engineers of the railways in the United States and Canada, replies being received from 39 roads:

QUESTIONNAIRE REGARDING THE USE OF EASEMENT CURVES.

To what extent do you employ easement curves?

What type of easement curve do you use?

Do you use easement curves for all degrees of curve, or do you restrict their use to curves of a certain degree or sharper, and if so, what degree?

Is the length of easement curve based upon the train speed as well as the degree of curve, and if so, how?

Is the easement curve established by your engineer corps or by the supervisors?

Is the use of the offset method or the method by deflections given preference?

Do you employ the string method of establishing easement curves in existing tracks?

Are the limiting points of the easement curves defined on the ground by permanent markers and do these carry the date as to full elevation and rate of run-off?

Are easements introduced at the time a new line is constructed or subsequently?

A brief summary of the replies, abstracted from the above mentioned journal, follows.

Only one of the 39 railroads replying reported no use made of easement curves. The extent of the use of spirals, as reported by the 38 lines which use them, is somewhat varied, but in general it may be said that they are used on main-line, high-speed tracks in nearly all cases. The classification of these lines as tabulated is as follows: On all lines, 4; on practically all lines, 9; on main lines and important branches, 2; on main lines, 7; on high speed tracks, 6; "limited use," 1; replies indefinite, 9.

Another field for variation in usage relates to the minimum degree of curvature for which it is deemed necessary to provide easements. The replies to this question are classified as follows: On all curves of 1° or over, 11; curves of 1° 30′ or over, 1; curves of 1° 45′ or over, 1; curves of 2° or over, 11. The replies from six roads indicated a more elaborate classification. Thus, the Canadian Pacific Ry. spirals all curves of 2° or over on main lines, but only curves of 4° and over on branch lines. On lines of the Pennsylvania System west of Pittsburgh, all curves of 2° or over are spiraled, but on lines carrying trains at speeds in excess of 40 miles per hour, the minimum limit of curvature is reduced to 0° 45′. Obviously, the faster the speed the greater the refinement necessary in easements. However, a study of the table does not show that the roads handling a larger proportion of high speed traffic are given to providing spirals for flatter curves than roads with slower trains.

Many Forms of Spirals in Use.—The spiral dates back to early days in railway building. Rankine made references to it. Wellington developed some simple approximations. In 1880 the Holbrook spiral was first made public and in 1882 Searles published the first edition of his "Railroad Spiral"—"to reduce the well known theory of the cubic parabola or multiform compound curve to a practical and convenient form." Since then a multitude of variations have been developed and put to use on the different roads.

In 1911 the American Railway Engineering Association adopted for inclusion in its manual of recommended practice an easement curve devised by J. B. Jenkins, valuation engineer of the Baltimore & Ohio R. R., which is known as the 10-chord spiral, but from the results of this investigation it would appear that this effort of the association to effect uniformity of practice has not been as successful as has been the case with some of the other standards published in the manual. Only two roads report the use of this particular form of spiral; of the other replies, 11 name the Talbot spiral; 8 favor the Searles transition curve and 11 use the rather general term "cubic parabola." Three replies do not indicate a preference for any particular type of curve while the others report a variety of easement so that, in all, curves with 12 different names are mentioned.

This variety may be explained in part by the fact that the true cubic parabola is a matter of intricate mathematics, approximations of which are to be had in a variety that affords a most fertile field of operation for the mathematician. Without doubt the 10 chord spiral of the American Railway Engineering Association has not received as wide a use as is warranted by the merits of this particular form of transition curve.

How the Length of Spirals Is Determined.—Another important matter in the discussion of spirals is the determination of the length, which involves a number of considerations, among which the most important is the distance required for an easy run-off of the superelevation. On new location in easy country, there is no limit on the length to which the easements may be extended. In difficult country a long spiral introduces complications.

Broadly speaking, this problem involves the inter-relation of curvature, speed and superelevation which are not properly a part of this discussion. Consequently, the question concerning this matter in the questionnaire was stated simply as: "Is the length of the easement curve based upon the train speed as well as the degree of curve and if so, how?" Answers to this question showed that 25 railroads consider speed as well as degree of curve, while 9 determine the length of the easement from the curvature alone. Five replies were indefinite as to this question or reported varying practices. On three roads the length of the spiral is determined directly from the speed and curvature through the formula $L = K V E$, where L is the length of the spiral curve in feet, K is a constant, V is the velocity of the train in miles per hour and E is the superelevation of the curve in inches. The constant K was given in two cases as 1.0 and in one case as 1 1/3.

On a number of roads the length of the spiral is made directly proportional to the elevation of the circular curve, the rules to this end calling for 40 ft. to 66 ft. of transition curve to each inch of superelevation. For convenience these rules are commonly expressed as ½ in. or ⅝ in. for each 30 or 33-ft. rail length.

No discussion of easement curves is complete without some consideration of the means provided for a permanent record of the spiral locations and of the information supplied to track forces for maintaining the alinement and superelevation. It was for this reason that the questionnaire included the question, "Are the limiting points of the easement curve defined on the ground by permanent markers and do each carry the data as to the full elevation and rate of run-off?" To this question 12 roads replied that such permanent markers were provided with complete data; 11 stated that markers were provided without any data; 3 reported the use of stakes; while 10 roads replied that no markers were provided; one road reported a variable practice while another stated that the location of the spirals was carefully referenced and recorded.

Raising a 500-Ton Concrete Culvert

A washout on the line of the Rochester & Syracuse Ry. undermined the entire footing of a reinforced concrete culvert. The manner in which this culvert was successfully raised to its original position is described in the Electric Railway Journal by Mr. D. E. Crouse, Chief Engineer.

The flood undermined the entire footing of the culvert and the south end of the culvert dropped about 4 ft. Before the high water subsided timbers were placed over the culvert to carry the railroad traffic, and as soon as the flood abated the normal stream was pumped out dry in order to make an inspection of the damage and ascertain how repairs could be made in an economical and satisfactory manner.

In order to keep the stream below the foundation level, a 3-in. centrifugal pump was used on the south side and a 4-in. centrifugal pump was placed on the north side of the bridge. It was found that the entire footing was undermined and that the culvert was practically resting on the tips of the wing walls. As there were no fractures in the concrete, it was determined to try and jack the culvert up to its original position and then replace the foundation. Earth was excavated from the sides of the culvert in order to free the batter and jacks were then placed under the entire footing course. Approximately 900 tons capacity in jacks was used and the culvert was successfully raised to its original position without a single fracture developing in the concrete.

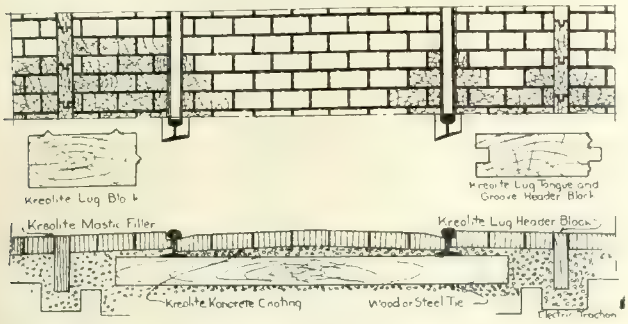
With the culvert in place a new footing course was run in and the tracks were removed. The repairs as outlined cost $650, and a replacement of the culvert which otherwise would have been necessary would have cost about $4,000.

Reducing Pavement Maintenance on Car Tracks

Mr. P. J. O'Neill, Railway Engineer with the Community Traction Co. of Toledo, writing in Electric Traction, describes some improvements in the way of car track paving which have had an appreciable influence in keeping down the cost of maintenance. The following is abstracted from his account:

Although the street railway is supposed to maintain the pavement only to a point 18 in. outside the outer rail, in practice it is usually found impossible to renew ties or otherwise disturb the company's share of the pavement without disturbing considerable of the pavement which the city maintains. This means that the company must either replace a portion of the latter or enter into an endless wrangle with the city authorities. The result is that the street railway company is ultimately compelled to maintain considerably more pavement than is called for under the franchise.

Header Blocks for Separating Street Railway Paving from City Paving.—To eliminate this extra expense, the use of header blocks between the street railway portion and the city portion of the pavement has been developed (see sketch). If these headers performed no useful function other than that of providing a segregation of that portion of the paved area maintained by the street railway company, the slight increase in initial expense would be well worth while. In actual practice it has been found that both the street railway's portion and the city's portion stand up much better when entirely separated by properly installed header blocks, due to the complete separation or the areas which are subject to unequal impact and thrust.


Kreolite Lug Block
Kreolite Lug Tongue and Groove Header Block
Kreolite Mastic Filler
Kreolite Lug Header Block
Kreolite Konkrete Coating
Wood or Steel Tie
Electric Traction

Plan and Section of Kreolite Lug Block and Tongue and Groove Header Block, Showing How Street Railway Paving Is Separated From Balance of Paving.

In Toledo a creosoted wood header block has been used on one street for the past 8 years to separate the street railway company's brick paved area from the adjoining areas which are paved with sheet asphalt. In this particular instance the street railway portion has settled from 3 to 5 in., but this has in no way disturbed the city's portion of the pavement. At the present time the Kreolite wood header block is being used on practically all new work. These blocks are 4-in. by 8-in. by 12-in., the 12-in. depth allowing the header to penetrate 8 in. into the concrete base when 4-in. creosoted wood blocks are used as the paving material; thus insuring the stability of the header blocks. These blocks are now made with a tongue and groove as shown in the illustration, which insures a proper alignment and gives additional stability to the pavement structure.

Maintaining Paving at Crossings.—The question of maintaining the pavement in and around crossings and other special work has always been a very serious one, particularly in connection with the tightening of bolts and other routine maintenance where the cost of removing and replacing the paving material frequently equals or exceeds the cost of the balance of the work. To overcome this item of expense, Mr. P. H. Farrell, roadmaster for the Community Traction Co., developed a series of removable panels or sections which can readily be removed and replaced whenever it is found necessary to tighten joints, replace bonds, or do other work below the surface of the pavement. This idea has proven to be so successful in practice that Mr. Farrell has taken out patents on this type of pavement and these sections are now offered to other companies under the trade name, "Kreolite Wood Block Krossings." These sections are built to fit the particular location for which they are intended and may be built in track department yards under royalty agreements or may be ordered direct from the manufacturers.

The construction consists of a creosoted tongue and grooved planked flooring cut to fit the opening between rails to which are toe-nailed the creosoted wood blocks which form the paving surface. The entire section is surrounded by a 3-in. by 3½-in. creosoted header which acts as a binder for the paving material and serves to stiffen the entire panel. The thickness of the plank base and the height of wood blocks used is regulated by the height of rail in the special work. For example, with a 6-in. rail the plank base is made from 3-in. stock with a 3-in. wood block paving to give the proper height for use with the rail in question. The entire section rests upon the ties so that it moves freely with any deflection in the track thereby preventing any heaving or displacement. In the center of each section a ring is bolted to the floor to provide a means of lifting out sections with a derrick. In the absence of a derrick two men can easily pry up and remove a section with ordinary pinch bars.

Creeping of Railroad Rails

In our issue of Nov. 17 last we printed an abstract of a paper on the above subject, presented by J. A. L. Waddell, before the American Society of Civil Engineers. Abstracts of the discussion on this paper were given in our issues of Jan. 19 and March 16. Further discussions on the paper are given in a reprint issued recently by the American Society of Civil Engineers, which also includes Dr. Waddell's closure. In this Dr. Waddell summarizes as follows the information obtained from the discussions:

A.—High rail ends, even on new track, cause creeping.

B.—It is the opinion of a number of track experts that the splice-bars should not be used as rail-anchors. In other words, they should not be slot-spiked to the ties, but should be free to slide on their bearings.

C.—One should not attempt to anchor against creeping in both directions by means of the same tie.

D.—More rail-anchors are required to withstand creeping than are generally used, even on the best of tracks.

E.—When steel creeps up grade on a single-track line, due to unbalanced traffic, this tendency is far greater at the lower end of the grade than elsewhere.

F.—Even joints are less conducive to creeping than staggered joints.

G.—It is possible that the creeping evil can be cured by means of a rigid attachment gained by bolting long angle-bars to the rail at the center of the panel and by slot-spiking to the ties. This method should be given a thorough trial.

H.—It is possible also that short angle-bars tightly bolted to the rail and spiked or screw-bolted to a number of ties per panel will check creeping. This method, too, should be given a fair trial.

I.—The adoption of the "bull-head" or "dump-bell" rail used in Europe would aid in the elimination of creeping; and this method should be tested and its economics determined.

J.—It is not advisable to attempt to check creeping by rolling a "projection, lock, or anchorage" on the bases of T-rails.

K.—There are only three successful types of anti-creeper in common use, but this by no means indicates that still better ones cannot be devised.

L.—Whether it is practicable to stop rail creeping entirely by the present anti creeping devices is still a mooted point.

M.—Whether rail creeping can be effectively checked through the use of spikes is also still a mooted point.

N.—Anti-creepers with their lower ends buried in the ballast and entirely independent of the ties have been proposed, and are worthy of a thorough, practical test.

O.—The merit of any rail-anchor should be judged by its efficiency in preventing rail movement and not by its price or ease of application.

P.—Rail-anchors should be attached to each rail as it is laid and not afterward at some more convenient time.

Q.—Angle-bars should not extend beyond the edge of the base of the rail, in order to permit spiking through the ordinary tie-plate.

R.—Although the "deadmen" suggested by Dr. Waddell are disapproved as being cumbrous, troublesome, and expensive, his pile anchorage, placed in front of a group of closely spaced ties which are then [illegible] to the rails by long angle bars leaving a [illegible] for rail expansion directly behind [illegible] with the anchorages spaced at such intervals as are found to be necessary by experience, would probably prove an effective device for inexpensively stopping excessive creeping on cheap track, especially when the motion is in one direction only. It would be well to give this suggested scheme a fair trial before passing on it an adverse judgment that would rule it out of use.

S.—Belittling of the evils due to rail creeping is unwarranted and is conducive to a postponement of their correction.

T.—There should be no hesitation about spending any reasonable amount of money in the elimination of rail creeping.

U.—Closer co-operation between the designers of track and the designers of rolling stock would be conducive to the elimination of some of the rail creeping.

V.—An urgent necessity exists for a further study, on an elaborate program, of the phenomenon of rail creeping, its causes, and its elimination; and no organization is so well fitted to do this work as the American Railway Engineering Association.

Placing Concrete Beyond Reach of Derrick Boom

The picture, reproduced from The Miami Conservancy Bulletin, shows what a skilful derrick artist can do in an emergency. A concrete bucket is shown in midair (the derrick boom which supports it being out of sight above), in the act of dumping its load of nearly 3 tons of mass concrete for the outlet conduit walls at the Lockington dam of the Miami Conservancy District of Dayton, O. The form below, into which the concrete is seen falling, was in this case too far away from the derrick to be reached by the regular procedure, and with only a comparatively few remaining yards of concrete to deposit, it did not pay to move the derrick to a new position. Hence the novel procedure shown. By hauling and slacking alternately on the boom line, keeping time to the natural pendulum motion of the bucket suspended from the boom end, the bucket was set swinging to and from the derrick foot. The load was dumped just as it reached its extreme outward swing, as shown in the picture. It was a 1 1/3 cu. yd. bucket—36 cu. ft., which at 150 lb. to the cubic foot, gives 5,400 lb., or 2¾ tons, to the load of concrete. It was a "guy derrick," with 120 ft. mast and 105 ft. boom. The derrick artist was Mr. Ed. Hines. The work was done in the spring of 1919.

"Throwing the Bucket"

Prices Still Higher Than Freight Rates

In spite of the recent sharp drop, average prices, according to the Railway Age, are still on a higher basis than freight rates. This is shown in figures just compiled by the Bureau of Railway Economics. The following table is based on the wholesale price index number of the Bureau of Labor Statistics, and gives a relative freight-rate index number based on average receipts per ton-mile.

Year or month.	Average railroad receipts per ton mile. Actual.	Average railroad receipts per ton mile. Relative.	Index number of wholesale price.
1913	.719	100	100
1914	.723	100	100
1915	.722	100	101
1916	.707	99	124
1917	.715	100	176
1918	.849	118	196
1919	.973	135	212
1920	1.052	146	243
September, 1920	1.151	160	242
October, 1920	1.226	171	225
November, 1920	1.263	177	207
December, 1920	1.209	168	189
January 1921	1.192	166	177

Up to the close of 1920 rates lagged far behind prices. It is only since the drop in prices began that the margin between increase of prices and increase of rates has narrowed. For 1920, as a whole, prices exceeded rates by almost 100 points, and even in January of this year prices were 11 points higher than rates.

Traffic in the last four months of 1920, with increased rates, was heavier in the United States than during the corresponding period of the three previous years. The depression which set in was therefore not an effect of increased rates; it came from causes which have produced business depression all over the world.

Application of Acetylene Torch to Restoring Outworn Machine Parts

An ingenious application of the acetylene torch to restoring an outworn steel shaft, has been lately perfected by Mr. Wm. McIntosh, Master Mechanic of the shop of the Miami Conservancy District of Dayton, O. According to the April Miami Conservancy Bulletin, the method produces what is in effect a new bronze bushing welded to the shaft and replacing the outworn surface. The old shaft is first turned in the lathe over the worn portion to a smaller diameter, "necking" it down thus about ⅛ in. Bronze is then fused to the surface of the neck by the acetylene torch until the diameter is a little greater than it was originally. The fused new bronze surface of what was the neck is now, of course, rough. This surface is now turned down to its original diameter, making what is in effect a new shaft, but with a bronze bearing surface at the journal instead of a steel one. This method has been successfully applied to heavy shafts like the 6-in. swing shafts of the large dragline excavators on the conservancy work; also to dredge pump shafts, which in some designs are peculiarly liable to quick wear on account of the sifting of fine sand into the bearings from the material going through the pump. The same method has been successfully applied also to refacing the nut which takes the end thrust of the drum shaft on a dragline shaft, when the friction clutch is thrown in. Many other applications will suggest themselves to those interested. The method gives a very inexpensive replacement of a worn part, which in many cases—as in the swing shaft above noted—may have cost a good deal of money and would otherwise have to be thrown away.

The Fallacy of Competition in a Regulated Monopoly

A movement has been started in the state of Washington to repeal the "Necessity and Convenience Act" passed by the legislature of last year which would again throw public utilities open to competition in any district which a rival company might care to enter. The experience of California and the judgment of the California Railroad Commission are expressed in an article in the April 15 issue of the Journal of Electricty and Western Industry by E. O. Edgerton, the former president of that commission. Mr. Edgerton's article follows.

Experience has shown that it is decidedly in the interest of the public that state utility commission should have power to prevent competition between public utility companies.

In practically all of the public utility acts or laws defining the powers of commissions there is included provision for compelling any person or corporation who desires to enter the field already served by an existing public utility to first obtain authoriziation so to do from the commission. Acting under this power, the California Railroad Commission, together with practically all the commissions in the United States which have such power, has adopted the rule that where a public utility company is giving adequate service at reasonable rates a competitor will not be permitted to enter the field.

It is now demonstrated that competition in public utility service and rates has not resulted in good service nor in low rates except for temporary periods, and always competition ends with waste and loss which is ultimately borne by the consumer.

The idea that competition is an automatic regulator of rates has proven fallacious. If real competition occurs rates are lowered by the company seeking to take business away from its rival, not on a basis of what the service costs but by lowering rates for the purpose of annihilating the competitor. For real competition to continue, each company in turn must reduce its rates below the other, because the moment they reach the same level of rates competition would cease. Therefore the company which is the stronger inevitably in the end destroys its rival or a point is reached where a realization comes to those who operate the companies of the folly and loss of such competition and consolidation is brought about, usually by the stronger absorbing the weaker company, and if competition has gone far enough, both companies are crippled and put in a position where they cannot adequately serve the public.

Furthermore, under modern conditions it would be a practical impossibility to persuade investors to provide sufficient money to parallel a large existing utility when the only hope would be that by constantly lowering the rates regardless of the cost of the service sufficient business could be obtained to destroy the rival. In other words, the investor would be asked to risk his money with no hope of reasonable returns thereon during the competitive period and with the inevitable prospect staring him in the face that some settlement finally would be made which undoubtedly would result in a loss of a part of his investment.

One serious result of throwing the field wide open to competition is that a designing and unscrupulous promoter can, by obtaining a franchise upon the promise of lower rates or better service, and without any substantial investment on his part, so shake the credit of the existing utility through the fear of investors that competition may occur, as to compel the existing company to buy him off. This opens a fruitful field for the blackmailer with no resultant good to the public.

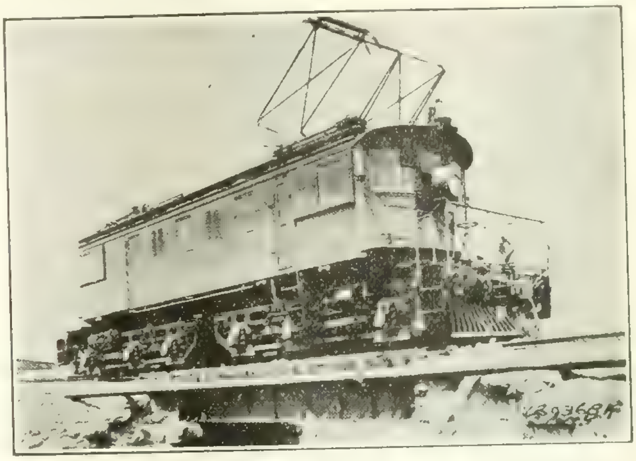
Also it should be seriously considered that to take from a commission the power to prevent competition takes from state authority representing the people the power to determine this important question, and places it in the hands of the individual who through entirely selfish motives may at any time destroy competition which he himself has created by selling out to the rival. It must be realized that the state has no power to compel any individual or company to continue competition.

The people must ask themselves this question: Shall they themselves, through their representatives the public utility commission, determine the vitally important question as to whether or not there shall be competition, or shall determination of this question be placed in the hands of individuals who of course will be actuated by selfish motives.

Electric Locomotive for Paulista Brazil Railway

The first Baldwin-Westinghouse freight locomotive for the Paulista Railway Co. in Brazil has been completed and tested. The passenger locomotives are nearing completion. This marks a milestone in the electrification of one of the most important lines in all South America.

These locomotives are to be used in main line freight service on the Paulista Ry. which is the main broad gage trunk line of the most prosperous and productive part of the state of Sao Paulo. These freight locomotives weigh 105 metric tons, and have six driving axles each equipped with one 280 HP. direct-current motor, arranged for operation with two motors in series on the 3,000-volt line. They are designed to handle trailing loads up to 700 metric tons over a line having a maximum grade of approximately two per cent.



Baldwin-Westinghouse Electric Locomotive Built for Paulista Railway of Brazil.

The locomotive illustrated is equipped with M. C. B. couplers for testing purposes but will later be equipped with Continental draft gear, and arranged for vacuum train brakes.

Enormous quantities of the coffee, beans, rice, cereals, and cattle are transported over this line by thoroughly modern and efficient railroading methods.

The Army Mule in the World War.—Some interesting figures on the losses by death among mules as compared with horses during the World War are given in a recent issue of The Military Engineer. From July 1, 1917, when the United States Army first received animals in France up to Nov. 11, 1918, the percentage of losses among mules was 10.88 per cent, while the losses among horses reached 25.37 per cent. The losses from July 1, 1917, to June 28, 1919, among mules were 13.12 per cent, while it ran to 27.97 per cent among horses. Figures compiled on both horses and mules from July 1, 1917, to Aug. 31, 1919, when the American forces in Germany had disposed of practically all of their surplus animals, show a loss of 26.1 per cent. A further comparison shows that even though animals are not exposed to the rigors of campaigns that replacements in rather large figures are essential to the upkeep of the army. From April 6, 1917, to Nov. 11, 1917, the loss among horses was 9.5 per cent, while among mules it was only 3.7 per cent. From the beginning of the war to June 28, the losses of mules were 4.6 per cent or less by 10.3 per cent among mules than among horses. A remarkable array of mules took part in the World War in the United States Army. There were 124,137 of them in the United States, and of that number 18,596 went overseas and actually took part in the war. Added to this lot were 11,036 from Spain, 8,992 from France and 6,974 from England, a total of 45,418. Many of the mules purchased from England and a number secured from the French had been bought in the United States by those countries. But those secured from Spain were the product of that country.

Reclamation of Old Railway Material

Judging by a committee report in the Proceedings of the Thirtieth Annual Convention of the American Railway Bridge and Building Association, the railroads of this country have been learning much in the way of economy from the use of reclaimed and second-hand material, particularly in the bridge and building material. Several roads have saw mills where old lumber which is sound or even partly sound is worked over into smaller sizes and shorter lengths.

The report states that the Chicago, Milwaukee & St. Paul Ry. is utilizing all timber taken from old structures to the best possible advantage. Bridge stringers that are too short for use in standard openings are resawed to sizes that will make sills for hand car houses, coal and oil houses, and outbuildings around smaller stations, and skids in the lumber yard. This material is given a treatment of carbolineum at the time it is resawed. Bridge ties are also resawed and pieces that are free from defects are used to make spacing blocks between ties on iron bridges while such as are defective are used in loading concrete pipe to prevent the sections of pipe from coming in contact with each other. Much of the above material is also used for car stakes. The rippings from the resawing are used to make crates for material that cannot be shipped open. The usable portions of brace plank are cut to lengths in multiples of 2 ft. and are used in highway crossings or sent out to concrete crews for use as runways or platforms on which to unload material. Cedar pile heads are sent to the mill and returned as shingles. Piles that have been pulled because of line changes and that are in good condition are used as foundation piles under masonry. At the company's Milwaukee shops a great deal of second-hand bridge material is worked up for flat car doors, and such as is not good enough for that is converted into coal and grain door boards. At the Tomah plant much economy results through the use of locomotive cranes for handling, loading and unloading second hand bridge stringers, ties, timbers and piling. Second-hand 1-in. lumber is sorted into thre grades; first grade, all lumber that is considered suitable for concrete forms above the ground level; second-grade, such as can be used for concrete forms below the ground line; third grade, all short pieces or such as are split or have defects that can be cut out are used in the manufacture of boxes such as are used by the store department for shipping switch bolts and other material, and works off very rapidly. All 3-in. by 6-in. lumber is sorted into two grades, putting into the first grade such as can be used for concrete forms while the shorter lengths are classed as second grade and used as car stakes. All of this material is graded at the time of unloading and each grade is kept separate where it can be gotten at readily.

The Grand Trunk R. R. reports that during the last few years a considerable number of light steel bridges have been taken out of service and that these are worked over and used in many ways, particularly for overhead highway bridges. A small shop has been instituted and is constantly engaged on this kind of work. Partly worn ties recovered from bridge decking are used again, but without resawing. Worn out valves are repaired and put back into service.

Following is an outline of the practice on the Lehigh Valley Ry.: Lumber taken out of bridges and trestles is sorted, separating the partly good and the good material from that which is of no further use. It is then sent to the division yard where the partly good lumber is sawed to separate the good from the poor, producing various sizes of material for use at bridges and buildings, concrete forms, etc. Some of the larger sizes can often be used full size by cutting off decayed ends. A small sawmill has been installed in the shop at East Buffalo for this purpose and has proven a good investment. Material has been reclaimed in this way that in previous years was discarded and burned. It is reported that in one case, out of 21,192 ft. B.M. of old timber, 13,047 ft. was reclaimed at a cost of $100, or an average of $7.70 per M ft. This material, if purchased new, would have cost from $56 to $88 per M ft. B.M.

On the Baltimore & Ohio R. R. reclamation of material has been practiced for a number of years. At Martinsburg and Zanesville large shops have been organized for the reclamation of old bridges, frogs, switches, track appliances, water station material, turntables, hand cars, baggage trucks, track scales and miscellaneous maintenance of way work. The shop at Martinsburg has been in operation for a number of years and has very clearly demonstrated its practical value and economy. In the rebuilding of bridges old spans are strengthened for branch lines and highway bridges. While if it were not for this shop, the road would be compelled to sell such spans at scrap value, as work of this kind would not be undertaken by the larger bridge companies. The cost of the work has been running approximately 40 per cent of what new bridges would cost after allowing scrap value for the material. Where the old spans are not considered of sufficient value for rebuilding, they are cut up and the web plates and any angles for which further use could be found saved. The angles and plates, being drilled throughout, are usually of insufficient value to justify their saving. Short turntables of 60 ft. and under, instead of being scrapped, are worked over and girders inverted and the necessary floor system installed for highway bridges. Where an 80-ft. or 100-ft. turntable is taken out on account of deterioration, a new or second-hand table is installed and the old table sent to this shop, where it is worked over, the necessary strengthening done and it is held in stock for future use. Second-hand value is placed upon the material and it is estimated that the cost of putting it back in first class condition is approximately 40 per cent of the cost of a new table, allowing for its value as scrap, at which price it would otherwise have to be disposed of. It is found in the reclaiming of this material that a large amount of stock is obtained for use on coal tipple, chutes and aprons, slide plates for track work and miscellaneous repairs for steel work on bridges and buildings, at a price very far below what it would cost if purchased new and which would otherwise be scrapped. On water station work it was found practicable to rebuild a great number of pumps at a price far below what it would cost to purchase new, including the scrap value of the pumps.

Sand and Gravel Production in 1920.—Though many producers reported that their output had been curtailed from 10 to 30 per cent on account of inability to get railroad cars, the total quantity of sand and gravel produced in 1920, according to figures of the U. S. Geological Survey, was nearly 78,000,000 tons, or about 7,000,000 tons more than in 1919. The total value increased from about $46,000,000 to more than $62,000,000. The production of building sand increased nearly 4,000,000 tons, and the average price per ton the country over rose from 56 to 66 ct. The output of molding sand increased more than 1,000,000 tons and the value more than $3,000,000. Glass sand, which is rather high priced, rose from an average of $1.97 a ton in 1919 to $2.20. Of the total production 2,144,000 tons were glass sand valued at $4,722,000; 4,890,000 tons were molding sand valued at $7,473,000, and 9,361,000 tons were classified as other sand valued at $8,546,000. The following table showing the production of building sand and gravel includes preliminary estimates for 1920 made by L. M. Beach, United States Geological Survey, Department of the Interior.

Year	Building sand		Gravel	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1918	19,686,885	$ 9,772,556	28,704,606	$13,563,310
1919	21,969,736	12,296,664	34,606,671	19,561,877
1920	25,943,000	17,052,000	35,549,000	24,901,000

Production of Explosives in 1920.—The total production (excluding exports) of explosives in the United States during the year 1920, according to reports that the U. S. Bureau of Mines has received from manufacturers, was 537,954,750 lb., an increase of 120,320,280 lb., or 29 per cent over the total output in 1919. The production for 1920 is segregated as follows: Black blasting powder, 254,879,825 lb.; "high" explosives other than permissible explosives, 229,112,084 lb.; and permissible explosives, 53,962,841 lb. As compared with 1919, these figures represent an increase of 41 per cent for black powder, 15 per cent for high explosives, and 39 per cent for permissible explosives. The reports show that all classes of consumers used larger quantities of explosives in 1920 than in 1919, the principal increase being in coal mining. This industry ordinarily consumes over 80 per cent of the total production of black powder and permissible explosives and 15 per cent of high explosives or over half of these three classes combined. The large increase in the quantity of explosives used at coal mines was occasioned by the greater output of coal during the past year, the quantity being 645 million tons, or nearly 100 million tons in excess of the output in 1919.

Methods and Costs of Steam Shovel Mining at Properties of Nevada Consolidated Copper Co.

Open cut mining by steam shovels has been under way at the Copper Flat Mines at Ruth, Nev., of the Nevada Consolidated Copper Co., since August, 1907. An interesting account of this work is given by Mr. Arthur B. Parsons in a recent issue of Mining and Scientific Press, from which the matter in this article is taken.

Steam shovel mining may be considered as consisting of four principal operations, namely, breaking the ore or capping, loading it, transporting it, and disposing of the capping. Obviously, the economical and efficient handling of material is the principal problem. So far as the mechanical operation is concerned, the stripping is not essentially different from mining, except that the valueless capping is transported by means of 20-cu. yd. side-dumping cars to the waste-dumps, the ore being loaded directly into standard railroad cars to be hauled to the concentrator.

Method of Putting Down Drill Holes.—The object is to shatter the rock (both ore and capping) sufficiently to enable the steam-shovel to pick it up readily. A certain amount of "dobying" will be necessary to break large rocks, but it is desirable to reduce this to a minimum and thereby to avoid delay in the operation of the shovels. The Nevada Consolidated rock has the reputation of being unusually soft, and some of it is; but there are streaks of hard material mixed with the softer.

The blasting is done, exclusively in 6-in. churn-drill holes, bored from the bench above. These holes are necessarily vertical; usually they are 55 ft. deep, thus extending about 5 ft. below the grade (assuming a 50-ft. bank) to assure the breaking at least to the level of the lower bench. This obviates difficulty with unbroken projections above the grade-level that interfere with the laying of track for the shovels and trains. The interval between holes varies with the character of the ground, but the average distance from the edge of the bank is 10 ft. and the space between holes is usually 35 ft.

The equipment comprises 11 No. 5 Keystone drills, with coal-fired boilers. This drill is strong, fast, and reliable; with a crew of two operators; that is, a runner and a tool-dresser, one 55-ft. hole per 8-hour shift is not an unusual average for experienced men. In prospect-drilling, after a depth of 150 or 200 ft. has been reached, progress is slower, of course; 15 ft. per 8-hour shift is a good record. At the collar of the hole an 8-in. steel casing, 6 or 8 ft. long, is sometimes inserted, where the ground has been shattered for a few feet by the previous blasting. The casing also serves to guide the bit until a good start has been made; it may or may not be removed after the hole is complete. The average speed of the churn is from 50 to 60 drops per minute. A bailer made of 4-in. pipe-casing with a valve on the lower end is used to remove the sludge at intervals. Sometimes in hard ground it pays to bail with every foot of progress, but every 2 ft. is generally often enough. In prospect or development holes the sludge is saved as a sample for assay.

Special Gang for Blasting.—All blasting is done by a special set of men in charge of the blasting foreman. The first step is to "chamber" or "spring" the hole; that is, to make a pocket at the bottom to receive the blasting charge. This is done in three or more stages by detonating in succession increasingly large charges of low-freezing 40 per cent powder; first 8 or 10 sticks, then a quarter of a box, three-quarters of a box, and, if necessary, two boxes are used. The success of the chambering can be determined by a simple contrivance consisting of a piece of bell-cord 60 ft. long, at the lower end of which is attached a cylindrical piece of wood of 4-in. diameter and 3 ft. long, center-weighted with lead. This is used to sound the hole. Water serves for tamping.

For the blasting charge 300 to 700 lb. of powder is used, the quantity depending upon the nature of the ground and the burden on the hole. Since 1919 two-fifths of the total quantity used has been ammonia or nitro-starch detonating powders, between which there is no particular preference; and three-fifths has been ordinary black blasting powder. Prior to that time a much larger proportion of the more expensive powder was used; but exhaustive comparative tests convinced the officials that the net cost of breaking was considerably lessened by the increased use of black powder. Some of the heavier sulphide ore requires that the stronger explosive be used exclusively; moreover, a small amount of detonating powder (approximately 2 per cent of the charge) is used in each hole to make the explosion not only certain but as effective as possible.

The following data show the results of one competitive test, and indicate the comparative cost:

Kind of powder.	Number of holes.	Material (in place) broken, cu. yd.	Powder used, lb.	Powder per cu. yd. broken, lb.	Cost of powder per cu. yd. broken in cts.
Dynamite	41	97,391	47,516	0.488	0.0799
Black powder	41	102,454	56,555	0.552	0.0686

The following figures show the consumption of powder during the first six months of 1920:

Tons of ore and capping broken	3,601,683
Pounds of powder used	778,852
Pounds powder per thousand tons	216
Tons material per pound of powder	4.62
*Cost of powder per ton of material	0.03114
Total drilling cost per ton material	0.00804
Labor cost of blasting per ton material	0.00496
Total cost of powder, drilling and blasting, as above	0.04414

*Includes freight from Bacchus, Utah; Roberts, Calif., or Hercules, Calif.

Results from Cordeau-Bickford Detonating Fuse.—Ordinary waterproof fuse with No. 6 caps was employed at the outset, but this was displaced by electric firing, using No. 8 exploders. Recently, however, Cordeau-Bickford detonating fuse has been used exclusively. It consists of a small lead tube filled with trinitrotoluene and carefully drawn to uniform size. It cannot be discharged by friction, fire, or ordinary shock; it is detonated only by means of an ordinary blasting cap. The average rate of speed of the impulse is 17,500 ft. per second, so that when Cordeau is used, the explosion is practically instantaneous. Cordeau acts as a detonator, as well as a fuse, and no cap is used with the powder; the line of Cordeau functions as the detonator after it has once been "exploded" by means of an ordinary cap or electric exploder, to which it is connected by means of a special brass sleeve. The advantages of this detonating fuse are: (1) Any number of holes can be detonated simultaneously by means of a single cap and an appropriate circuit of Cordeau. (2) By running Cordeau through the entire charge the speed of detonation is accelerated and the shattering effect of a given quantity of powder is increased, thus either permitting lighter charging or more effectively breaking the rock with the same charge. (3) Loading of holes can be done more quickly and with greater safety than when fuse and a detonating cap in a primer are employed in the usual way, and, moreover, the danger from unexploded caps and powder in missed holes is entirely avoided.

Steam-Shovel Loading.—Nine steam shovels are included in the equipment; all are of Bucyrus make. Five are 95-ton class C shovels with 3½ cu. yd. dippers, 25-ft. dipper-sticks, and 34-ft. booms. Originally these were built with 18-ft. sticks and 28-ft. booms, and carried 5-yd. buckets. In order to enable the shovel to take a wider cut, thereby reducing the shifting of track necessary, the sticks and booms were lengthened. The expectation was that the 5-yd. buckets could be retained, but it soon became evident that this was impracticable; so the smaller buckets were substituted. In addition, there are three 95-ton Class B, and one 70-ton Class B shovels all fitted with 3½-cu. yd. buckets. All the shovels are operated by steam, and the boilers are fired with coal. Each is equipped with a 1-kw. Schroder turbo-generator to supply direct current for lighting purposes.

The crew actually engaged in the operation of the shovel consists of eight men, including one shovel engineer, one crane man, one fireman, on coal-passer and four pitmen. The specific duty of the pitmen is to take up the track behind and to re-lay it ahead of the shovel as progress is made in the removal of the bank. They are, however, available for any work in connection with the shovel operations. During the first half of 1920 the average performance of all the shovels on ore was 306 tons per hour; the shovels on capping loaded 152.2 cu. yd. per hour during the same period. This includes the time consumed in moving the shovel and all lost time incidental to delays of the trains hauling the rock.

An important item of steam-shovel equipment is the dipper. The Missabe dipper with the Vanderhoff front and [illegible] made by the American Ma[illegible] is used at Ruth. One [illegible]-ton dipper [illegible] the [illegible] devices operated continuously for 720 days and moved 1,000,000 cu. yd. of material before being discarded. The advantages [illegible] great strength, economy [illegible] the small amount of time required for making repairs.

A bench, 20 ft. wide after the blast, provides adequate room for the loading track at the proper distance from the path of the shovel when equipped with booms and dipper-sticks of the dimensions stated above. The shovel loads the material from the side between the bank and its own course, as well as immediately ahead, so that the advantage of the long boom in permitting a wide cut is apparent. The height of the bank, 50 ft., has several advantages: 50 to 55 ft. is an economical depth for churn-drilling; it is not so high that the broken rock is likely, when blasted, to bury the loading track on the shovel-bench, nor so low that an unreasonably small quantity of ore is broken.

Disposal of Waste.—More than 30,000,000 cu. yd. of capping has been hauled already to the four principal dumps in the vicinity of the pits. A 20 cu. yd. all-steel dump car is used for this work.

"Railroading" plays an important part in the pit operations. The mining company has 19.53 miles of standard gage track in the shovel-pit area, and 8.95 miles additional is comprised in approaches to the pit, sidetracks in the assembly yard, and miscellaneous tracks at Ruth. The maximum grade of the tracks is 4 per cent, this being found near the mouth of the pit, where the tracks from the different benches switch toward the assembly yard. At least 85 per cent of the track is on a grade of less than 2 per cent.

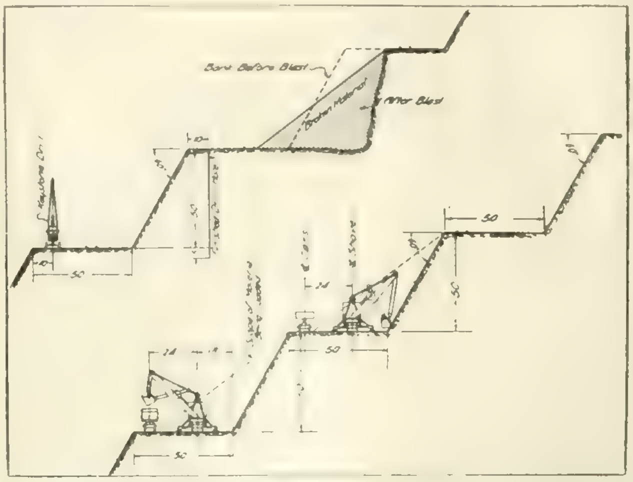
Transportation of the Ore.—The ore is loaded by the shovels directly into 50-ton gable-bottomed steel cars. Tracks for these cars and the 20-yd. waste cars are required on each bench in the pit. These tracks form individual loops that converge outside the pit. In addition there are the tracks leading to the various dumps. The loaded ore cars are delivered to the assembly yard, where the trains are made up for transportation to the concentrator. During 1916, 1917, and 1918 the efficient dispatching of traffic was an important factor in maintaining production, and the convenience of the track arrangement in the pit proved decidedly helpful.

The Nevada Consolidated Co. operates 16 locomotives at Ruth. All are of the "saddle tank" type, without tenders, except the last one, which is an ordinary switch engine. Coal is used exclusively as fuel. Each locomotive has a turbo-generator, similar to those on the shovels, except that they are of 335-watt capacity instead of one kilowatt.

Uses of Steam Crane and Repair Car.—Among other items of heavy equipment are a steam crane, a "wash out" or repair car, and a Jordan spreader. The crane is of 30-ton capacity with a 44-ft. boom, made by the Bay City works. It is used for unloading coal into stock piles and for transferring it, and for cleaning track when covered by heavy blasting. For this work a clam-shell bucket of 2-yd. capacity is used. Another purpose that the crane serves to good advantage is the loading of churn drills on a standard flat car for transfer from one bench to another. A suitable sling is prepared and the churn drill is lifted bodily and placed on the car; the same method is used in unloading at the point where the new hole is to be drilled.

The crane is also used for moving track in the pit. After each cut the track, upon which the trains of ore cars run, must be shifted closer to the new bank. This is done by means of the crane operating from the bench next above. A sling, made with hooks on each end of a 40-ft. cable, engages a portion of the track. Fastened to the loop of the sling is a pulling line operated directly from the drum of the crane. Successive lengths of track are dragged laterally a few feet at a time, the crane moving under its own power to maintain the proper direction of pull. In this manner the track is gradually worked to its new position. As much as 1,500 ft. has been shifted in six hours with a force of four laborers and the crew operating the crane.

The "wash out" car is an old box car fitted with an acetylene welding outfit, a power drill press, a 15 HP. steam boiler, a small steam pump, a supply of hose and pipe, sundry jacks and chain blocks, and a large assortment of hand tools. The original purpose of the car was to enable the convenient washing of the boilers of the shovels as they stood in position. The plan was elaborated, and now all sorts of minor repairs to the shovels, churn drills, and even cars, are done expeditiously, a large proportion on equipment that previously was hauled to the shop. Repeated trips back and forth are thereby avoided.



Sections of Levels Showing Working and Blasting Conditions.

Efficiency of Operations.—The following data on the efficiency of operations during the first half of 1920 are based on an average output of approximately 6,000 tons per day, and are fairly representative of what can be done. It should be noted that the unit used with respect to mining is the "ton of ore"; with stripping it is the "cubic yard of waste."

MINING.	
Tons of ore mined	1,028,592.0
Shovel shifts	428.6
Tons of ore per shovel hour	300.0
Tons of coal used on shovels	814.0
Tons of shovel-coal per ton of ore	0.00087
Pounds of powder per 1,000 tons of ore	259.41
Locomotive shifts	920.7
Tons of ore per locomotive-hour	139.6
Tons of coal used on locomotives	3,126.12
Tons of locomotive coal per ton of ore	0.00304
STRIPPING.	
Yards of waste moved	1 191,246.0
Shovel shifts	978.29
Yards of waste per shovel-hour	152.2
Tons of coal used on shovels	2,193.1
Tons of shovel-coal per yard of waste	0.00184
Pounds of powder per 1,000 yd. of waste	428.58
Locomotive shifts	2,174.88
Yards of waste per locomotive-hour	68.47
Tons of coal used on locomotives	7,495.06
Tons locomotive coal per yard of waste	0.00629

Cost of Stripping and Removing Overburden.—Table I shows the operating cost for the 6-year period from 1913 to 1919 inclusive. It should be noted that the cost of mining does not

TABLE I.—COST OF STRIPPING AND REMOVING OVERBURDEN.

	1913.	1914.	1915.	1916.	1917.	1918.	1919
[illegible]	[illegible]	[illegible]	2,758,350	3,974,952	3,011,728	2,617,771	1,674,865
[illegible]							
[illegible]	[illegible]	[illegible]	0.0738	0.0823	0.0907	0.1026	0.0903
[illegible]	[illegible]	[illegible]	0.0434	0.0426	0.0552	0.0647	0.0517
[illegible]	[illegible]	[illegible]	0.1070	0.1229	[illegible]	0.1862	0.1777
[illegible]	[illegible]	[illegible]	0.0066	0.0071	0.0077	0.0095	0.0100
Miscellaneous	0.0678	0.0581	0.0577	0.0460	0.0428	0.0490	0.0568
	0.3428	0.3171	0.2885	0.3009	0.3443	0.4120	0.3865

COST OF PRODUCING ORE.

	1913.	1914.	1915.	1916.	1917.	1918.	1919.
[illegible]	[illegible]	2,513,241	2,991,782	3,337,570	[illegible]	2,711,743	1 390,903
[illegible]	[illegible]	0.0416	0.0374	0.0421	0.0485	0.0527	0.0586
[illegible]	[illegible]	0.0304	0.0208	0.0248	0.0320	0.0395	0.0257
[illegible]	[illegible]	0.0301	0.0251	0.0297	0.0458	0.0667	0.0605
[illegible]	[illegible]	......	......	......	......	......	0.0245
[illegible]	[illegible]	0.0497	0.0691	0.1104	0.2075	0.2580	0.1544
	[illegible]	0.1518	[illegible]	0.2370	0.3338	0.4169	0.3237

include the arbitrary charge added to cover the item of prepaid stripping, but does include every other cost except depreciation and depletion. Prior to July 1, 1918, the stripping suspense charge was 30 ct. per ton, but the necessity for maintaining the flatter slope, together with the increased per ton cost of removing the overburden, made it advisable to add 10 ct. to this charge. The remarkable increase in the cost of producing ore during 1916, 1917, 1918, and 1919 reflects the comparative inefficiency of labor during this period; and in a still greater degree the increase in taxes. The item of taxes is not included in the figures for 1919. During 1915, Federal, property, and bullion taxes totaled only 0.2 ct. per pound of copper or 4 ct. per ton of ore, as compared with 15.81 ct. per ton in 1918.

Annual Meeting of American Association of Engineers Endorses Nation Wide Activities for Engineers

The annual meeting of The American Association of Engineers, in session at Buffalo, New York, May 9 to 11, 1921, went on record as endorsing the following activities:

Favoring an engineer on the International Boundary Commission.

Favoring a national board of classification for engineering schools.

Against laws permitting corporations to practice as engineers.

Favoring a census of highway traffic.

Favoring a continuance of Federal aid to highways.

Favoring Phipps bill increasing Federal aid allotment in public land states.

Favoring national financing of reclamation work.

Favoring sanitary engineers on public board of health.

Directing advance copies of annual convention reports be prepared.

Favoring a minimum of two weeks' notice by both parties in case of separations in employment.

Providing for committee to plan employment service and payment therefor.

Favoring increasing the membership from all classes of engineers.

Providing a committee to amplify statement of the ideals and objects of the association.

Thanking the city of Buffalo and the Buffalo Chapter for the courtesies extended to the convention.

The officers elected for the ensuing year were H. O. Garmon, chief engineer and consulting engineer with the Indiana Public Utilities Commission, president of the association; A. N. Johnson, dean of engineering at Maryland State College, vice-president; A. S. Morris, auditor, capital expenditures, C. & N. W. R. R., second vice-presiden. E. F. Ayres, Webster L. Benham, Garrison Babcock, Morris Bien, G. M. Butler and W. R. McKeen were elected directors. C. A. Hoglund, C. D. Hartman, W. R. Smith are the new auditing committee.

The convention was attended by 150 delegates representing 200 chapters.

The program of the meeting consisted of hearing reports of various national committees, including those on various employment, railroad, industrial, federal, salaries of engineers in public service and in teaching service, water power and conservation, highways and the numerous other activities of the organization.

The most important development of the convention was the outlining of a program for the activities of 200 chapters of the association scattered throughout the country, based upon the various activities of these chapters during the past year, along the lines of employment, civic activities, legislation, ethics, education and compensation.

Numerous organization matters were taken up, including the division of fees between the chapter and national headquarters, on a basis of 60 per cent to the chapter and 40 per cent to the national office.

On the afternoon of the second day, a trip was made to Niagara Falls by 130 delegates.

At the banquet on May 10, addresses were delivered by L. K. Sherman, H. O. Garmon and Frances A. Kellar, who spoke on "Americanization and Man Power."

Salt Lake City, Utah, was selected as the convention city for next year.

Portable Air Compressors in Tunnel Work

Portable air compressors are giving good service in driving gangways in rock and connecting them by rock holes to the coal beds in the Mammoth and Buck Mountain mines of the Lehigh Valley Coal Co. Five compressors are in use, the initial cost complete (air hammers and hose included) was $14,550. The methods of using these outfits and the advantages are described by Mr. F. H. Wagner, Lost Creek, Pa., Division Superintendent of the Lehigh Valley Coal Co., in the Employes Magazine of that company.

The compressors were placed at convenient locations, either along a widened portion of a gangway free from the gangway track or at a gangway and tunnel junction, so near the work that short lengths of line could be used. In general the size of pipe used is 1½ in. on the 10x10-in. compressors and 1-in. on the 9x8-in. machines. Mr. Wagner is of the opinion that the larger of these machines gives better results than the smaller, as they furnish enough air so that four jackhammers can be used at one time with fair results. When only three hammers receive air from the line and the transmission distance does not exceed 600 ft., excellent speed in drilling is obtainable. With 9x8-in. compressors only two hammers can be used with success.

The cost of the upkeep on the five compressors for one year amounted to $480, all five being used and seeing hard service. The upkeep cost on a centrally-located plant in the same division amounted to $640. The average life of short-length pipe lines running from a portable compressor is 18 months. In contrast the main air lines from a centrally-located plant in certain sections must be practically renewed three times. On a 2½-in. line the upkeep cost in 18 months was about $460, against $100 for the lines on the portable compressors.

These machines can be handled as easily as a mine car and have been utilized in two different sections of the mine in the same shift, the compressor being moved to its second location when the drilling in the first was completed. As received from the manufacturer these compressors had too short a wheelbase. In another make of machine the compressor and electric driving units overhung the frame. This was overcome by rebuilding the compressors on a regular car bottom with the standard wheelbase of the colliery.

These portable units need comparatively little care. The colliery electrician looks after the electrical end of the machine and a machinist attends to the mechanical or compressor end. Constant attendance is not required, but, like all other machinery, these units need a reasonable amount of supervision. They do not, however, demand the undivided services of an attendant, as does a centrally-operated air plant.

The use of portable compressors naturally is not confined to rock gangway and rockholes, as they are suited to rock work of any nature as well as to the drilling of particularly hard seams of coal.

What a Public Service Commission Has to Contend With

The difficulties that confront a public utilities commission are well set forth in the following extract from a rate decision handed down recently by the Maine Public Utilities Commission:

> Controlled as this commission is by the law which declares that rates shall be reasonable to the customer, influenced as we ought to be by a desire to treat the company with fairness and to enable it properly to perform its public duties, this commission, like any similar commission, stands in a very unenviable and delicate position. Very naturally if rates are sought to be increased each and every user of the service being affected resents and resists the increase, and no matter what may be the facts presented some customers, and oftentimes the majority of the customers, will not be convinced of the necessity or reasonableness of any increase whatever. Facts and figures do not seem to count with some, and perhaps it is no more than to be expected that during these times of high and increasing costs every addition to the burden seems not only unreasonable but unnecessary. Each person hopes and has been hoping that the burdens will be lessened, and any addition is accepted in a resentful spirit. We have been criticised severely during the past three or four years. We shall no doubt continue to be criticised, but we should be unworthy of holding the position we do if the members of this commission were in the least respect swayed either by criticism or by any other improper influence. We have a duty to perform and must perform it with fairness and courage.

Tractor Sled Haulage in Alaska

By E. M. LAGRO

No section of the Northern hemisphere [illegible] such marked progress with relation to the [illegible] of modern machinery and appliances as has Alaska. The many natural barriers and obstacles which have delayed and retarded the advance of progress in this region have now been greatly overcome by mechanical means.

Freight rates which have been absolutely prohibitive in the interior Alaska points will soon be reduced from $350. a ton to approximately $25 a ton. This will result in a flat saving of $325 over the present prevailing prices. It is a direct result of the advance of the new government railroad. The new rate will be effective, it is believed, with the completion of the railroad which extends from the tide water to the interior. Increased activities will result and mining machinery can soon be shipped to Fairbanks, Nenana, Fort Gibbon, Ruby and other interior points. At present most of the freight to these places is sent by dog teams or "mush" over trails from the sea port towns of Valdez and Cordova.

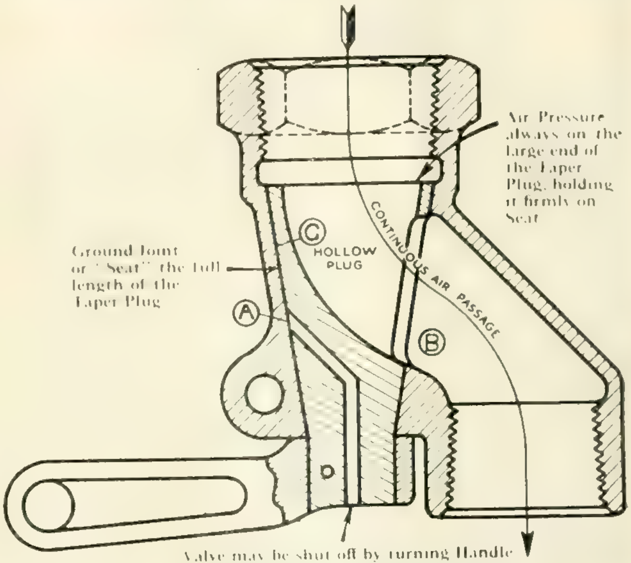
One of the marked improvements in transportation in this district is the "caterpillar" train which operates on a 60 mile haul. These tractors, manufactured by The Holt Manufacturing Co., are the same as those supplied the allied government during the war. They haul approximately 50 ton of perishable foodstuffs and supplies over the snow and ice. A recently perfected radiator frost pad which protects the motor of the tractor enables them to operate even when the temperature is 40° below zero. Another engineering asset of this particular machine is the articulated roller frame and the equalizer bar which join the two portions of the tractor truck and supporting roller. This latter factor enables the tractor to conform to the unevenness of the ground and to climb over obstacles and yet assures perfect traction without slipping. It is one of the refinements and modifications made possible by war experience.

This novel means of transportation represents the solution of the problems which have confronted the engineers in this district for many years and by this means the railway construction camps (in some cases isolated in the interior) are assured of a systematic replenishment of commissary stores. Another great factor the district officials state is that freight can be handled by the "caterpillar" train across the Broad Pass which is not feasible for railroads.

Tractor Drawn Outfit Operating Over Snow in Alaska.

Pressure Seated Air Valve for Compressed Air Installations

The Cleveland Pneumatic Tool Co. of Cleveland, O., has recently brought out an air valve for general use in air service which contains several new features. The sectional drawing illustrates the new valve, which is designed to eliminate air losses through leakage in transmission. It was determined to design a valve in which the air could not come in contact with the seat—thus avoiding replacement of seats, and also to utilize the "air pressure" as a "seating agent" to hold the valve plug on its seat, thus eliminating packing, gaskets, stems and springs and reducing the valve parts to three, i. e., body, plug and handle. This was successfully accomplished by using a "hollow taper plug" with the large end uppermost, the air entering at the top, passing through and out of an opening in one side of the hollow plug into the supply chamber which connects directly with the air hose without the air coming in contact at any time with the valve seat—ground joint—which is the outer wall of the plug as indicated by the letter "C" on the drawing. The long "arrow" shows the direction of the air in its travel through the wide unobstructed air passage of the valve which is free from any angle turns to impede its progress. The short arrow indicates the "point" on the large end of the plug where the air pressure is constant, forcing the taper plug against the walls of the valve body forming a perfect seat. The valve is provided with a unique waste arrangement to allow the accumulated pressure in the air hose to escape to atmosphere when the valve is shut off as shown by air ports "A" and "B" on the drawing; this is to safeguard the operator, who when disconnecting the hose from valve often receives a gush of air in the face and accidentally gets scale or grit in his eyes. The new valve has been subjected to very severe service tests under both high and low air pressures, the high pressure being 500 lb., as well as submerged water tests and is stated to have successfully passed the most exacting tests that could be devised on liquids under pressure and on acetylene gas lines.


Air Pressure always on the large end of the Taper Plug, holding it firmly on Seat
Ground Joint or "Seat" the full length of the Taper Plug
C
HOLLOW PLUG
CONTINUOUS AIR PASSAGE
A
B
Valve may be shut off by turning Handle either way around. When shut, the Air-port "A" registers with Supply Chamber "B," allowing air trapped in hose to escape to atmosphere

Cleco Pressure Seated Air Valve.

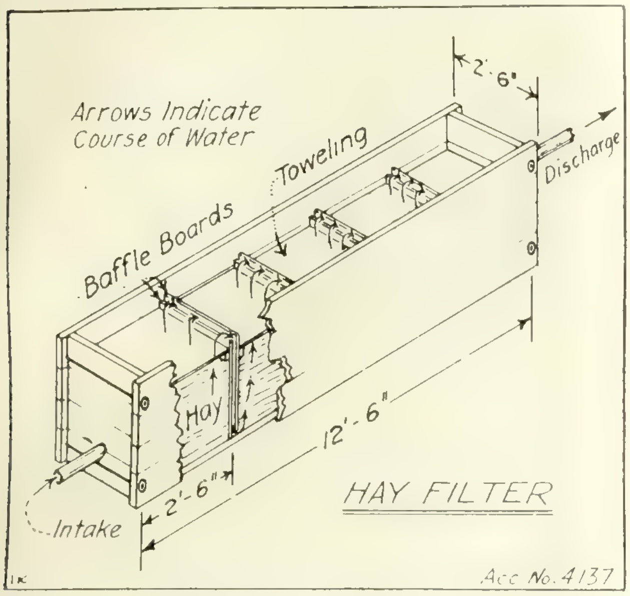
Hay Screen for Filtering Boiler Feed Water of Tug Boats

A filter for removal of sediment from boiler feed water that has given good service on the river tug boat of the Miami Conservancy District of Dayton, O., is described in a recent issue of The Miami Conservancy Bulletin. It was introduced on the Miami river job by H. A. Hanson and V. H. Tucker of the scow and tug boat service, who had used it successfully on the New York state barge canal.

The filter consists of a long rectangular wooden tank, divided into compartments by cross partitions, through which the feed water is made to circulate, entering at one end and leaving at the other, passing through repeated filters of hay and turkish toweling in the course of its journey. Five filters are shown in the illustration but the number is not arbitrary. In some cases probably fewer would be sufficient. In each the direction of flow is upward—an important consideration. The five compartments are separated by double baffle boards, the two boards in each case 2 or 3 in. apart, sufficient to leave space for the water between them, the water passing in all cases over the top of the board nearest the inlet, and under the bottom of the other, thus delivering the water always at the bottom of the next compartment.

Each compartment is simply packed full of the hay, up to the level of cross cleats near the top, these cleats providing support for a finer screen made of the turkish toweling. This is made by tacking the toweling to a rectangular frame after the manner of mosquito netting.

The water in its passage—always upward, through the filter compartments—leaves sediment in the meshes of the hay and upon the under side of the toweling rather than upon the upper side. This may seem a small matter, but it means a difference between cleaning the filter twice a week, and cleaning it several times oftener; in other words, it stops the deposition and packing of a thick layer of silt on the top of the left hand towel screen, with consequent rapid clogging of the flow.



Hay Filter for Boiler Feed Water.

On the Dayton job the use of this device has meant the elimination of a shutdown during the week to clean sediment from the tug boat's boiler; one boiler cleaning, during the regular week-end shutdown, being sufficient for this period.

The filter was cleaned twice a week, very simply, by removing the towel screens and washing them off with a small hose, the hay not being removed, or indeed treated in any way except to remove and replace it at long intervals with clean material. It should be understood that the filter is for sediment only; lime or other deleterious chemical ingredients being of course untouched.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

C. R. Cummins Co. of Cleveland and St. Louis were awarded 6 miles of double track work by the Big Four R. R. Co. in Indiana, approximately 300,000 yds. of material to be moved on this job. Roy Hatfield will be in charge. The C. R. Cummins Co. were also low bidders on 1,640,000 yd. of ditch work in Scott County, Mo. Will do this work with two drag lines, which will be looked after by A. C. Duesin. Paul Grafe, their St. Louis representative, is not overlooking anything in the way of new work.

Frank Bunch, Iowa City, Iowa, has 180,000 yd. of grading on 18 miles of State road work to sublet.

Another good old timer, Henry W. Kolkmeyer, who was born in Jefferson City almost 83 years ago, and resided there ever since, died April 20th. During the early days of railroad building he held contracts for construction of the Missouri Pacific and other Missouri railroads, and he later handled railroad construction contracts in Southern Missouri and Northern Arkansas. He was one of the contractors for the construction of the Governor's mansion and many of the old substantial buildings in the city stand as witnesses to his work.

Mulvill Bros. of Alton, Ill., has 30,000 yd. of drag line work, excavating a ditch near Springfield, Ill., to let.

Following a conference between city and government officials, the United States Government agreed to construct a 500 ft. dock on the river front in South St. Louis, similar to the North Market street dock, and costing approximately $400,000. Construction will begin before July 1 to make the appropriation available.

L. I. Viall has about finished his work on the Frisco R. R. at Sleeper, Mo. Has two shovels idle that he can place on work immediately.

L. J. Printy subbed 80,000 yd. of road work from Cameron, Joyce & Co. in Southern Illinois.

The East St. Louis Council awarded the contract for the repaving of Tenth street, from State street to St. Clair avenue, to the Concord Construction Co., the bid being $46,592.

Mrs. L. S. Cooper & Sons have moved their outfit on 45,000 yd. of Illinois State road work that they took from Cameron, Joyce & Co.

Rolla Wells, receiver of the United Railways Co., filed a petition in the United States District Court for authorization to spend $1,615,869.50 for construction and improvements in the current year. This amount includes $585,036 for improvements which were authorized last year, but are not yet completed. The chief new expenditure for which authorization is asked is $250,000 to build a new car shed at Broadway and Taylor avenue.

Wm. J. Danklif is building a reservoir at Edwardsville, Ill., for the Donk Bros. Coal Co.

T. J. Morris, Route No. 2, Carbondale, Ill., expects to finish his road work at that point in two or three weeks. Is in the market for some more grading.

P. J. Murphy, Moberly, Mo., was the successful bidder on section 1, Sny Levee District, at Hannibal, Mo.

J. W. McMurray Contracting Co. was awarded contract for abutments in Smoky Hill River, also a number of culverts on the M. K. & T. R. R. north of the Red River.

Jessie Stubbs has branched out in the contracting business. He secured Moehle & Kelly's teams and has them on a job near Randolph, Mo.

As a result of the activities of the Federated Roads Council of St. Louis and the efforts of this organization, extending over a period of six months, the contract for the construction of 16 miles of the Manchester road, leading from St. Louis to a point beyond Ellisville has been let by the St. Louis County Court. The contract was awarded to the Rich Construction Co., of which Louis Rich of 1530 Winstanley Ave., East St. Louis, Ill., is president. The cost of the construction of the Manchester road, under the contract will be $595,944. Rich bid $30,000 below the estimate.

Costello Bros. are at work on 28 miles of county road work between Irvington and Owensboro, Ky.

Jerry Connors of the New Era Construction Co. was low bidder on a nice piece of Illinois State road work in the eastern part of the state.

Keating Bros. and Al Gilliand have shipped their outfits on to the new road job that they were recently awarded at the Springfield, Ill., letting.

Contractors when in want of work or labor for their oufits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., or 501 Delaware St., Kansas City, Mo.

Higgins, Grinnell & Hoffman have taken 155,000 yd. of drag line work from Cameron, Joyce & Co. in southern Illinois.

Lewis B. Davis, of the Davis Contracting Co., and Davis Commissary & Supply Co., died here Wednesday evening, May 12th, from the effects of an operation. Mrs. Davis is going to continue the companies under the supervision of R. H. Couch, who has been their office man here for some time.

Hannan & Sutherland, 217 Breman Ave., St. Louis, have three pile driver outfits idle that they can place on work immediately.

Personals

W. V. Taylor has been appointed city engineer of Sarnia, Ont.

C. O. Thurman has been appointed city engineer of Phillipsburg, Kan.

N. A. Kemmish of York, Neb., has been appointed city manager of Alliance, Neb.

Delmont J. Schneider has been appointed city engineer and street commissioner of Pocatello, Idaho.

Earl C. Elliott, vice-president of the Wichita Water Co., has been elected city manager of Wichita, Kan., to succeed L. W. Clapp, resigned.

John M. Rice, formerly of Morris Knowles, Inc., has opened offices at 411 Oliver Bldg., Pittsburgh, Pa., where he will engage in an engineering practice.

Clyde L. Seavey, member of the California State Board of Control, has been appointed city manager of Sacramento, Calif., at a salary of $10,000 per year.

U. Stephens, formerly county engineer at Ballinger, Tex., has been appointed highway engineer of Road District No. 2 of Hill County, Texas, with office at Itasca, Tex.

John A. Kurtz of Kansas City, Mo., has been reappointed a member of the State Public Service Commission. His term is for six years and he is named chairman of the commission.

Edward R. Knowles, consulting engineer and fuel expert, is now associated with Murrie & Co., Inc., engineers, 74 Broadway, New York, in charge of pulverized coal and gas fuel engineering work.

John A. McGrew, formerly superintendent of the Saratoga Division of the Delaware & Hudson R. R., has been appointed to a new position of superintendent of maintenance with office in Albany, N. Y.

David Rose has resigned as county engineer of Koochicking County, Minnesota, to become district engineer of the State Highway Commission of the state at Bemidji. A. B. Peterson of Ericsburg was appointed his successor by the board.

H. H. Elliott, division engineer of the Kent division of the Erie R. R., with headquarters at Marion, O., has resigned and will locate in the west. He is succeeded by I. H. Schram, at present terminal superintendent, a position that has been abolished.

D. B. Steinman, formerly special assistant to Gustav Lindenthal, consulting engineer, later professor in charge of civil and mechanical engineering at the College of the City of New York, has opened an office at 25 Church St., New York, where he will make a specialty of service to engineers and architects.

G. W. Boschke has been appointed chief engineer of the Southern Pacific lines, succeeding William Hood, who has retired. Until a few months ago Mr. Boschke was chief engineer for the Oregon, Washington R. R. & Navigation Co. He has been serving during the past three months as assistant chief engineer to Mr. Hood.

T. J. Wyche has resigned as chief engineer of the Western Pacific R. R. on account of ill health, and is succeeded by G. H. Ballantyne, who has been construction engineer of the road for several years. Mr. Ballantyne was formerly engineer with the Tooele Valley R. R., and recently completed construction of the new San Jose branch of the Western Pacific R. R.

Col. Henry C. Nutt, who was chief transportation officer of the American Army of Occupation in Coblenz, Germany, has been elected president and general manager of the Monongahela Ry. and the Pittsburgh, Chartiers & Youghiogheny Ry. Col. Nutt has been a railroad man for nearly 40 years, having entered railway service in 1883 as a rodman on the Burlington & Missouri River R. R., of which he was assistant superintendent from 1894 to 1900.

Ralph D. Ballew, manager of the Westinghouse Electric & Manufacturing Co.'s branch office at Grand Rapids, Mich., has been appointed city manager of Sturgis, Mich. Mr. Ballew was graduated from the University of North Carolina, department of electrical engineering, in 1914, specializing in hydro-electrical plants [illegible] He was employed [illegible]

Obituaries

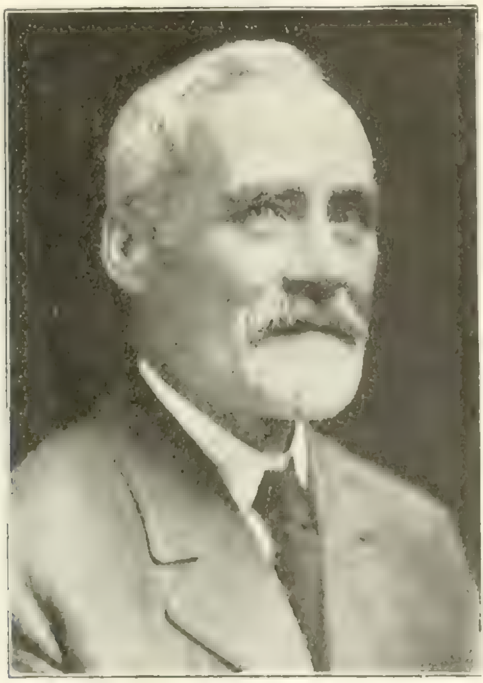
John T. Hurrop, [illegible]

Edward H. Widdicombe, [illegible] who [illegible] in that city [illegible] ago [illegible]

William Henry Davisson, who [illegible] has filled [illegible] of the Pacific [illegible] Commission, at San Francisco, Calif., died at his home in Oakland, Calif., May 3, 1921. He was born in Kalamazoo, Mich., Dec. 11, [illegible] Davenport, [illegible] Rock Island & Pacific [illegible] chainman in 1884. His unusual ability as an engineer was early demonstrated [illegible] He held many responsible positions in connection with the construction and development of this system's lines in the west. From 1896 to 1900 he was general roadmaster and in 1906 he became assistant chief engineer. In 1907 he was employed by the Chicago, Milwaukee & St. Paul Ry. and for two years had charge of very heavy construction work on the Puget Sound extension in the vicinity of Missoula, Mont. In 1910 he was appointed principal assistant engineer of the North Coast Ry., now a part of the Union Pacific system, and constructed the very difficult section between Ayer Junction and Spokane, Wash. He remained with this work until its completion in 1913. On Jan. 31, 1914, he was appointed field engineer by the Bureau of Valuation, Interstate Commerce Commission, in charge of roadway inventories of railroads in the Pacific district. He was subsequently promoted to assistant district engineer, which position he held at the time of his death. Mr. Davisson is survived by a widow and one son.

T. L. Smith.

Thomas L. Smith, founder, director and chief stockholder of the T. L. Smith Co., Milwaukee, Wis., died April 29, at his home in that city. Although Mr. Smith brought out a number of successful inventions during his life, he is probably best known to the world as the inventor and manufacturer of the line of Smith tilting mixers. Because of his activities in designing and producing mixers, pavers, excavators, crushers, etc., his career has a most unique significance in the field of construction and engi-[illegible]



Thomas L. Smith, Founder of the T. L. Smith Co.

Born in England, June 6, 1855, he came to this country with his parents at the age of 4. He received his early schooling at St. James Episcopal Parochial School, Milwaukee, and while still a boy moved to Watertown, Wis., where his father had established a machine shop and foundry. In his father's shop he learned the [illegible] Iowa. Although he had no high school education, he was graduated in 1877 with the highest marks ever awarded an Ames student up to that time, including fifteen perfect grades for full terms. During his four years at Ames he acted as instructor in the college machine shop, thus paying his own way and contributing to the support of his parents at home as well. After his graduation, at the age of 22, he was appointed instructor if the college in mathematics and bookkeeping. After several years in that ca-[illegible] engineering education in the Massachusetts Institute of Technology. In 1920 Iowa State College conferred upon Mr. Smith the honorary degree of Doctor of Engineering, in recognition of his accomplishments.

The early part of his career, immediately following his college [illegible] in drafting and engineering work with some of Milwaukee's largest manufacturers, including Allis-Chalmers Co., Filer & Stowell Mfg. Co., Pawling & Harnischfeger Co., C. J. Smith & Sons Co. and Kempsmith Mfg. Co. D. J. Murray Mfg. Co., Wausau, Wis., manufacturers of logging machinery, also employed him as chief engineer. During this period he invented the first really successful wood-carving machine.

Mr. Smith's interest in concrete mixers developed in 1898 and 1899 when he was conducting a school of engineering and mechanical drawing in Milwaukee. In 1899 Mr. Smith's invention of the Smith tilting mixer took definite form and the first machine was manufactured in 1900. It was a complete success from the very beginning. This first Smith tilting mixer gave ten years' hard service. That machine was the beginning of the success of Mr. Smith as a manufacturer. He took out patents and built additional machines. With assets of only $500 in 1900 the business grew so rapidly that in 1905 Mr. Smith organized a corporation known as the T. L. Smith Co., which today has assets of over $1,200,000.

The T. L. Smith Co. represents only one of Mr. Smith's successful business ventures. When the Sterling Wheelbarrow Co., West Allis, Wis., was a small, struggling concern, Mr. Smith purchased a controlling interest and within a few years developed that business to the point where it was the largest and most successful of all his holdings at the time of his death. The Smith Engineering Works, Milwaukee, manufacturers of Telsmith rock and ore crushers, is another company organized and developed to a high degree of success by the inventive genius and business ability of Mr. Smith.

His career was successful not only from a business standpoint but also from that higher standpoint of personal success. He never for one moment permitted his business success to interfere with his love and sense of duty for home, family and community. His rise in civic, Masonic and religious affairs kept pace with his business achievements. All worthy charity endeavors found him a cheerful and willing contributor. He loved music, art and literature and these were always his chief sources of pleasure and recreation. His purest treasure was his spotless reputation.

Industrial Notes

Norman DeWind has severed his connection with the Austin Mfg. Co., Chicago, and for the present is located at 935 East 49th St., Chicago.

Charles R. Pollard has resigned from the Trade Research Division of the Goodyear Tire & Rubber Co., Akron, O., to resume the office of secretary of the Alexander Milburn Co., of Baltimore, Md. Mr. Pollard was connected with the Milburn Co. in various official capacities for 10 years prior to joining the Goodyear Co. in 1919, and will take charge of the territorial development for the Milburn Co.'s products.

Leslie H. Allen, who has recently been with Fred T. Ley & Co., contractors, of Springfield, Mass., first as an industrial housing engineer and then as sales manager for New England territory, has joined the staff of the Portland Cement Association, 111 West Washington St., Chicago, as assistant manager of the Cement Products Bureau. Prior to joining the Ley organization Mr. Allen was for 12 years with the Aberthaw Construction Co. of Boston.

Last January the interests, along with all patents and patent rights of the Duntley Pneumatic Tool Co., were acquired by the H. O. King Co., engineers and tool makers, at which time Mr. King, president of the H. O. King Co., organized the Duntley-King Pneumatic Tool Co., an entirely new organization for the production of pneumatic tools and accessories. The new company is now in production on a full line of pneumatic tools and accessories, with general offices and factory at 1143-45 Diversey Parkway, Chicago, Ill.

The Post Tractor Co. of Cleveland, O., and The Whitney Tractor Co. of Upper Sandusky, O., have consolidated as The Post-Whitney Co. of Cleveland, O. The company is capitalized at $10,000,000 and the personnel of its officers is as follows: E. B. Cassatt, Cleveland, O., president; A. B. Whitney, Upper Sandusky, O., vice-president; C. B. Post, New London, O., vice-president; A. J. Tuscany, Cleveland, O., treasurer; F. R. LePage, Cleveland, O., secretary. The Post-Whitney Co. will maintain the plant at Cleveland, O., where the Post tractor will be manufactured, also the Whitney plant at Upper Sandusky, where the Whitney tractor is being built. The company will soon make an announcement of the purchase of a motor plant wherein will be operated its motors and transmissions.

The Engineering Advertisers' Association of Chicago held its May meeting on the 10th in the Fraternity Room of the Great Northern Hotel, Chicago. An instructive address on "Sales Analysis and Advertising Ratio Costs" was delivered by Prof. Horace Sechrist, director of the Bureau of Business Reasearch, Northwestern University, and supervising statistician of the United States Railway Labor Board. When his address was completed Keith J. Evans, president of the Engineering Advertisers' Association, threw the meeting open for general discussion, and many interesting questions bearing on advertising ratios were propounded by members and satisfactorily answered by Dr. Sechrist. In addition, the association was favored with a short address on gold and metal mining conditions by J. F. Callbreath, executive officer of The American Mining Congress, Washington, D. C.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Jacks.—Duff Manufacturing Co., Pittsburgh, Pa. Bulletin illustrating and describing this company's line of automatic lifting jacks.

Transits.—Buff & Buff Manufacturing Co., Boston, Mass. 16-page catalog illustrating and describing the essential parts of the Buff transit.

Excavator.—Keystone Driller Co., Beaver Falls, Pa. Bulletin describing the Keystone light traction steam shovel, equipped with three different buckets, skimmer, ditcher and clamshell.

Bottomless Power Scrapers.—Sauerman Bros., 322 S. Dearborn St., Chicago, Ill. 16-page pamphlet illustrating and describing the various classes of Sauerman bottomless scrapers, their methods of operation and their applications in handling sand and gravel.

Excavator.—T. L. Smith Co., 1160 32nd St., Milwaukee, Wis. 16-page catalog describing and picturing details of the Smith excavator and loader. One-half of the catalog is devoted to mechanical features of the machine. The other half of the catalog shows the machine in action under a wide variety of conditions—digging and loading soil, gravel and sand, plowing in frozen earth, excavating for basements, excavating beneath a completed building, on county road work, etc.

Building and Structural Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Below the Belt

In the production of pure disgust perhaps no form of graft exceeds that of the standard requirement imposed for the purpose of making a trade monopoly. It is not new; it is not confined to the building trades, in which our interest centers; it is used in various forms by politicians, manufacturers, dealers and labor organizations.

Last week we referred to the necessity of increased vigilance, aggressiveness and courage in the suppression and prevention of construction graft. We now call attention to a conspicuously flagrant instance of graft through the establishment and enforcement of standard requirements barring the use of anti-siphon traps in plumbing installations. Peculiar interest attaches to the case because, according to testimony before the Lockwood Committee in New York, not even the backing of Tammany Hall was sufficient to break through the defenses of the master plumbers, the union, and the soil pipe manufacturers. One may be pardoned for a little cynical pleasure in also finding that a biter was bitten, for it appears from the testimony that the very individuals who were so outrageously prevented from introducing a meritorious device were themselves bent upon excluding all other devices which might compete with theirs.

Here in brief is the story as revealed to the committee and reported in a New York paper. Since early in 1919 the Geco trap has been the only anti-siphon trap permitted by the Board of Standards and Appeals to be sold in New York City. According to Plumbing Rule 99 adopted Dec. 27, 1918, it does not require back venting, and this is said to save from 30 to 60 per cent of the piping on drainage jobs. Other anti-siphon traps have been on the market for 25 years, and though claimed to be entirely satisfactory in operation, have been kept out of New York through the character of the test required by the board. This is simply the testimony. The editors know nothing personally of the merits and demerits of the various devices.

The Cody Brass Works, Inc., control the rights in the Geco trap—the invention of the late George Cody. Exactly one-half the capital stock of the Cody Brass Works is owned by John A. McCarthy, former business partner of Charles F. Murphy, and now awaiting sentence after pleading guilty to violating the State Anti-Trust law; Philip F. Donohue, treasurer of Tammany Hall and protege of Leader Murphy; Frank J. Farrell, former owner of the Yankee Baseball Club, and James H. Naughton, close friends of Tammany leaders. The other half of the stock is owned by the Cody estate.

The Geco trap, in spite of its approval by the Board of Standards and Appeals, is kept out of New York City by the opposition of the large soil pipe manufacturers of the United States in combination with the master plumbers of New York and Local 463, Plumbers' Union, of Robert P. Brindell's Building Trades Council. The soil pipe manufacturers have put up the bars against the anti-siphon trap because it reduces greatly the quantity of vent pipes necessary, the master plumbers oppose it because it makes less work for them, and the journeymen ban it because it reduces employment.

During the examination of Frank S. Hanley, secretary of four associations of dealers in plumbing goods, there was read into the record a bulletin of the Greater New York Association of Jobbers and Plumbing and Steamheating Supplies appealing to its members and members of their associations to adopt resolutions of protest against the use of the anti-siphon trap.

A letter of the Central Soil Pipe Manufacturers was read and it said that the association, in conjunction with the master plumbers, had spent from $5,000 to $6,000 in opposing the introduction of the anti-siphon trap in this city.

Max Fischer, secretary of the Longacre Building and Supply Co., 20 West Forty-third street, told of the agreement between the master plumbers and the employers not to install anti-siphon traps and of the fines imposed on members for disobeying the agreement.

No master plumbers would even furnish bids for the installation of anti-siphon traps, he said. On one small alteration job, he said the vent pipe system cost $11,000 and the anti-siphon trap system would have cost $6,000. Not only does the anti-siphon trap save money, but in remodeling buildings it would avoid the disfigurement of structures.

In the work on the Strathmore building, 1672 Broadway, nearly $9,000 would have been saved, and $18,000 was actually spent on the back vent plumbing system.

Thomas McKeon, master plumber, of [illegible] West 170th street,

> [illegible] story, [illegible] he wanted [illegible] not permitted to do so. H[illegible] George Cody, inventor [illegible] his examination, [illegible] out the story of the Geco trap.
>
> [illegible] an architect [illegible] in spite of the fact that the anti-siphon trap had been approved by a committee of several architectural societies, strikes were called on two buildings where he specified its use. He said the anti-siphon trap was superior to the old vent-pipe system, and that he would prefer it even if there was no material saving in cost.
>
> Charles Ericson, a former secretary of the Master Plumbers' Association, was opposed to the anti-siphon trap, although he had not seen one in twenty years. He judged the trap only by pictures he saw of it. Minutes of the union showed that a committee was appointed to work with the union in a publicity campaign against the device.

Anti-siphon traps are in use in fifty [illegible] other cities and have been installed in the White House, the Congressional buildings, the large Atlantic City hotels and many other places.

Since the day when the wolf killed the lamb because the latter had eaten his grass, probably no malefactor has failed to find a pious reason for his acts, and it would be interesting to listen to the grounds offered in connection with the Geco trap. It might be like the not uncommon argument of the large competitor who, in stifling his smaller rival contends first of all that he is doing the rival a favor because the latter was foredoomed to failure, and the sooner he is relieved of his burden the better for him; and secondly that he is greatly benefitting the public because the competition of the smaller concern increases prices.

In conclusion we note some of the cases of this class which have come under our own observation. References to labor union restrictions of output and prohibitions of machines, and to cutthroat competition by large dealers are omitted. The makers of a certain electrical appliance secured the passage of a city ordinance requiring its universal installation as a safety measure although competent electrical experts insisted that it was unnecessary. The holders of certain drawbridge patents secured the adoption of specifications barring all designs but theirs. Portable houses were prohibited because of the fire risk, although other risks as great were allowed. A large milk dealer secured the passage of an ordinance requiring that any person selling milk, submit his product daily for inspection at the city hall thus barring scores of people with one or two cows from selling milk to their neighbors. The exclusive dealer in a certain line of building materials got regulations which practically barred all types of flue linings but the one sold by him.

Such practices are simply blows below the belt. How long will business tolerate such actions as are despised and debarred in the prize ring?

Resist Grafters in the Building Trades

At least 1 per cent of the estimated cost of all large buildings erected in Chicago is set aside for the payment of graft to labor union leaders. This was the testimony of a Chicago architect, Walter W. Ahlschlager, before an Illinois legislative committee that is investigating building conditions in Chicago. We quote from the Chicago Tribune:

> Mr. Ahlschlager, who was architect for the Sovereign, admitted he knew Goldberg had met the business agents in his office, but stated he did not know whether Krieg was present.
>
> "What did you think they were up there for?" asked Attorney Fleming.
>
> "Graft," replied the witness. "There is no doubt about that. That's easy. Goldberg had told me he had had trouble with these leeches from time to time."
>
> The architect declared he had made provision for graft when he drew the specifications for the hotel.
>
> "It was our custom in preparing a budget for a building to have a specific sum always set aside for graft," he said.
>
> "As a matter of fact that is what every architect in Chicago does, doesn't he?" asked Mr. Fleming.
>
> "That is what all architects do if they are careful."
>
> "That is a general condition that exists in Chicago and has existed for a long time, is it not?"
>
> "Yes."
>
> "Have you or your organization ever done anything to stop it?"
>
> "No."
>
> [illegible]
>
> "Yes, it is something that exists just like the roof on the building. We always took precaution to see that the interest and overhead did not eat up the principal."
>
> "How much do you set aside for graft?" asked Representative John P. Devine.
>
> "Usually about 1 per cent. For instance, the Sovereign Hotel cost about $800,000, and the graft was fixed at $8,000."
>
> "So you only missed it by $500?"
>
> "Yes, we were ahead $500."

It is almost incredible that many of the architects of Chicago have been parties in transactions such as this. No wonder Mr. Fleming asked, "Have you or your organization ever done anything to stop it?"

It is frequently argued by individuals that they are powerless to wage war against a well intrenched organization of grafters and that, in any event, it is cheaper to pay the extortion than to fight the extortioners. Even nations have been known to pay tribute to pirates for the privilege of navigating the seas unmolested by them. But the argument is not only fallacious; it is cowardly. Any organization of professional or business men that takes "the easiest way" in avoiding a conflict with grafters is scarcely better than the grafters themselves.

The rottenness in the building trades of Chicago and New York is appalling. We are startled not so much by the general existence of graft as by the apathy among professional and business organizations, an apathy that has permitted evils to grow from pigmy to gigantic proportions with scarcely a publicly uttered hint that this evil development was in progress. It is true that occasional statements have been made in private to the effect that labor union leaders in the building trades were blackmailing certain individuals and firms, but the natural inference was that this graft was like any other class of criminality—an occasional act of an occasional crook, and not the every day business of many men, as it seems now to have been.

The structural engineers, and indeed all professional engineers, in Illinois and New York, should at once join the architects in a determined effort to erase the evils that have brought into deserved ill repute the building trades of the two greatest cities in America.

Coordinating Factory and Farm

The industrial depression bids fair to simplify this year's problem of getting harvest and other farm hands, but this scarcely pleases the farmer, for the simplification of depression is not what he wants. Furthermore, the depression is not going to be with us forever, and when it is gone the same old problem will return. It will return assuredly, but this is not saying that the evils may not be remedied or perhaps in time even cured. The fact that year after year the nation gets by, managing in some way to harvest its crops, is pertinent, but is not an argument for leaving an admittedly bad situation alone.

The conditions of the problem are such as tend to make action slow. As it stands at present, the farmer is not in a position to provide as much work throughout most of the year as he has at seed and at harvest time. A majority of other seasonal trades require help at the same time as does the farmer, and the manufacturer whose efficiency of production depends in part upon approximately continuous operation of his plant throughout the year is certainly not to be expected to sacrifice his interests for the sake of helping the harvest. Much as has been accomplished and as may be hoped for the future from the use of machinery instead of men on the farm, there must always be a considerable number of workers, and the work must remain largely seasonal. The more intensive cultivation to which we are destined ultimately, will probably tend to the employment of more rather than fewer men per unit, thus to some extent offsetting the effect of machinery and improved methods.

A possible solution seems to lie only in the establishment of industries which can economically be closed down or curtailed during the busy farming seasons. Such industries might be found in new, and at present undeveloped, fields, or they might result from the revision or rearrangement of existing industries. To simply wait for them to develop would be like Mr. Micawber's waiting for something to turn up. The field of new industry holds a possibility only, and a faint one at that, for a general solution. The adjustment of existing business to the needs of the case might be done through governmental ownership and operation or through complete governmental control, but such procedure would involve a degree of socialism which few indeed believe would be beneficial or safe to try.

There remains the possibility of a private business, organized for the operation of farms in conjunction with other industry. This seems to hold some promise, and we believe that it is worthy the careful study necessary to determine whether it is worth trying. If such study gives an affirmative answer, then real trials should be conducted on the most promising combinations. Such a business would obviously require large capital, but we see no necessity of its being handled exclusively by one concern, of its being organized as a trust, or being experimented with on a grand scale.

Presumably the manufacturing business should be located near enough to the farms to permit of the operators having permanent homes, and to avoid the economic loss of having home buildings and equipment idle for considerable portions of the year. The character of the business must depend obviously on what raw materials are economically available, and farm products are naturally the first materials to suggest themselves. The milling of grain and the making of other food products (breakfast foods, beverages, dried and condensed farm products, canned goods, etc.) are conceivable. While some of them require operative forces during the farming season, others might be postponed almost entirely if adequate and efficient storage were provided, and nearly all involve finishing processes which could wait for considerable periods. Textile industries might find economic places in the districts from which their raw materials are supplied. Toy-making, brick and tile manufacture, and many others might be adjusted for operation when labor is most readily available.

Successful intermittent operation cannot be conducted in an industry having expensive plant installation and comparatively little labor cost. Therefore we must seek in general for those industries in which the ratio of labor cost to plant cost is the highest, and in which it is not necessary to accumulate large stores of expensive materials; while at the same time we must not forget that idle men entail as true a loss as do idle machines—only it is harder to locate. Some one's business success may result from his use of this hitherto lost man power.

Such a project as this should be of benefit to the workers in furnishing steady employment and desirable environments, but we do not suggest it as a philanthropic or altruistic undertaking. If it cannot succeed on its economic merits it ought to fail. As we have already said, we believe that it is worthy of investigation by persons desirous of finding new ways of profitably investing capital.

The "Declaratory Judgment"

It is reported that in April there became operative in Kansas a statute making possible the "declaratory judgment," that is, a court decree stating whether a given act is or is not legal in advance of the actual performance of such act. This should be of particular interest to contractors, as cases not infrequently arise—particularly in the handling of public work and the payments therefore—in which court decisions are necessary. In such cases the "declaratory judgment" promises a speedy, inexpensive, and safe guide to action as against the slower, costly, and sometimes dangerous method of first performing the questionable act, and then fighting it out in court.

The Kansas statute is worded to avoid the defect of the Michigan law which was recently declared unconstitutional because it tended to make bureaus of legal information out of judicial tribunals. We hope to be pardoned for expressing our wonder as to why a judicial tribunal should not dispense important legal information before the want of it gets somebody into trouble as well as after the trouble has happened. We are reminded of the case of the Western mayor (real case and real mayor) who protested that the energetic city librarian and the aggressive library board were "trying to make an educational institution of the library."

Examination for Appointment to Corps of Engineers, U. S. Navy.—The Bureau of Yards and Docks, Washington, D. C., has postponed the closing date for the receipt of applications for the examination for appointment to the Corps of Civil Engineers with rank of lieutenant (junior grade). The new date set for the receipt of these papers is June 11, 1921. The examination is open only to male citizens of the United States. A candidate, on Aug. 1, 1921, must have passed his 22nd birthday, and must not have passed his 30th birthday; he must have received a degree from a college or university of approved standing, showing that he has satisfactorily completed a course in engineering, and he must, on May 1, 1921, have had not less than 20 months' practical professional experience subsequent to graduation. The total annual pay is $3,222.

Book Reviews

Industrial Housing.—By Morris Knowles, Formerly Chief Engineer, Division of Passenger Transportation and Housing, Emergency Fleet Corporation, U. S. Shipping Board. 408 pages; 54 figures. McGraw-Hill Book Co., New York. 1920. $5.00.

The author had considerable experience in industrial housing while serving in the Emergency Fleet Corporation during the war. The present book is an attempt to chronicle "some of the conclusions from his experience." In his work the author was greatly impressed with the necessity for cooperation between the various professions, such as: the architect, the town planner, the landscape gardener, the engineer, the the sanitarian, the utility designer, the constructor, the realtor, the civicist and the public-spirited business representative.

It is not unusual for a book treating as wide a subject as the present one, while discussing ably and fully the technical side of the subject, to omit the financial, administrative and business ends of it. The author of the present book, however, emphasizes these phases of industrial housing, bringing out their importance in considering any housing project.

The book begins with a small historical review of industrial housing in this country and proceeds to a consideration of the fundamental preliminaries, such as: Advantages, cost, need for subsidy, organization, finance and technical program. The selection of the site and the development of the town plan are the next logical steps in the housing project. These include a study of the best length of blocks, minimum requirements for housing space, a rational method of planning the street system. A good deal of space is devoted in the book to the engineering and sanitary problems: Streets and pavements, water supply, sewerage and drainage, collection and disposal of town-wastes. Each problem is stated fully and data are given to help apply it to particular cases. A chapter is devoted to the consideration of gas and electric service. Examples are given from existing developments.

The layout of houses for families and buildings other than houses is taken up next. These chapters contain standards, minimum requirements for houses, building technique, details of construction, comparative costs of various types of buildings, the requirements and arrangement of various stores and services. An example is given to illustrate the determination of the number and kind of accommodations for a given number of employes and distribution of payroll.

In the next chapter, "The Administration and Supervision of Construction," the author gives an organization chart; a detailed technical program; a budget layout; forms of contract for construction and a discussion of construction problems. The last chapter is devoted to "Management of Industrial Towns." The author states his "firm conviction that permanently company-owned and exclusively company-controlled towns are theoretically undesirable civic units in the United States." Two types of industrial towns are discussed, the isolated and the suburban. The principles and functions of town management are not to be on paternalistic lines, but supported by the inhabitants of the town.

A brief bibliography and index close the book.

Cotten's Charts for the Design of Beams of Reinforced Concrete or Timber of Both Rectangular and T Form Based on a New and Original System of Transformation Ratios and Equivalents. Copyright, 1918 and 1921, by S. M. Cotten, 323 No. 20th Ave., Phoenix, Ariz. Supplied in blueprint form by author for $3.00

The set includes ten "Primary Charts" giving depths of beams for $n = 15$, $fc = 650$ and $fs = 16000$

$$\left(R = \frac{M}{bd^2} = 107.4 \right);$$

five "Depth Transformation Charts" giving coefficients to be applied to the "Primary Charts" as corrections to depths for cases of R other than 107.4; several other charts useful in designing T beams. Two charts are appended giving moments and reactions for beams both simply supported and fixed due to various positions of a concentrated load on the beam.

Fire Tests on Building Columns

[illegible] and fire-and water tests on bu[illegible] conducted at the Underwriters' Laboratories [illegible] by The Associated Factory Mutual Fire Insurance Companies, The National Board of Fire Underwriters and The Bureau of Standards, U. S. Bureau of Commerce, during 1916-1918, are reported in a book just issued by the three organizations.

The purpose of these tests was twofold. First "to ascertain the ultimate resistance against fire of protected and unprotected columns as used in the interior of buildings," and second to ascertain "their resistance against impact and sudden cooling from hose streams when in a highly heated condition."

In all, 106 tests were made, of which 91 were fire tests and 15 fire and-water tests. The fire tests include: (1) Tests of unprotected structural steel, cast iron, concrete-filled pipe and timber columns; (2) tests of columns partly protected by filling re-entrant angles and interior with concrete; (3) tests of columns protected with 2 in. or 4 in. of concrete, hollow-clay tile, clay brick, gypsum blocks, single and double layers of metal lath and plaster; (4) tests of reinforced concrete columns with 2 in. protection.

The columns were designed for a load of about 100,000 lb. The exposure to fire was produced by placing the column (under load) in a furnace with the temperature regulated according to schedule. Readings were taken of the temperature and of the deformations of the columns.

In the fire-and-water tests the columns after exposure to fire were exposed to the impact of a stream of water of measured duration and pressure. The tests include: (1) Structural steel columns protected by concrete, hollow-clay tile, gypsum block and plaster on metal lath; (2) reinforced concrete columns with 2 in. protection, and (3) unprotected cast iron columns. Columns that stood this test were afterwards loaded to failure.

To obtain information about the physical, chemical and thermal properties of the materials used in the columns and coverings, tests of these materials were made. Tests were thus made of structural, car and wire steel; cast iron, Portland cement, sand, coarse aggregate, concrete, lime, calcined gypsum, mortar, plaster and filling, hollow-clay tile, brick, gypsum block and gypsum wall-board. The results of these tests are tabulated in 36 tables placed in appendix D of the book.

The temperature measurements were made by the thermoelectric method. Some of the results of the tests are summarized below: s

AVERAGE TIME TO FAILURE IN THE FIRE TESTS.

Unprotected structural steel columns	20 min.
Unprotected cast iron columns	35 min.
[illegible] timber columns	40 min.
Unprotected pipe columns	50 min.
[illegible] protected structural steel	1¼ hours
Plaster protected structural steel	2 hours
2-in. hollow clay tile and brick protection	2½ hours
4-in. hollow clay tile and brick protection	3¼ hours
2-in. solid gypsum block protection	2½ hours
4-in. solid gypsum block protection	5½ hours
2-in. concrete protection	5 hours
4-in. concrete protection	8 hours
Reinforced concrete columns	8 hours

(Note.—8 hours was the duration of the fire test.)

Vertical Deformation (in 12-ft. 8-in. length of column).

Before failure	Steel column	⅛ in. to ¾ in.
	Cast iron column	[illegible] to 1 in.
	Reinforced concrete column	¼ in to ½ in.
At failure	From	2½ in. to 3¼ in.

Lateral Deflection.

[illegible]	[illegible]	[illegible] to 2½ in
	Reinforced concrete column	⅛ in. to ¼ in.
At failure	Steel column	1 in. to 15⅜ in.
	Cast iron column	3 in. to 9 in.

Results of Fire and Water Tests.

Duration of fire	Steel columns	45 min.
	Cast iron columns	22½ m. to 30 m.
	Concrete columns	60 min.

[illegible]

Steel columns	2¼ min. to 5 min., 30-50 lb. sq. in.
Cast iron columns	1 min., 30 lb. sq. in.
Concrete columns	5 min.. 50 lb. sq. in.

Protection other than concrete usually washed away; concrete [illegible]

The columns were afterwards loaded to failure:

[illegible] About [illegible] [illegible] load

[illegible]crete columns......About 4½ times the allowable working load

[illegible] ...ing load

Steel columns........About 4 times the allowable working load

The time to failure due to fire stated above is to be reduced by about 1/3 to obtain fire resistance periods. This deduction is made to allow for incidental variations in material and workmanship of columns and coverings, and differences in load and fire conditions that cause variations in results with nominally comparable columns.

Fire resistance periods for various materials and coverings are derived in the book and placed in tabular form.

The appendices contain photographs of columns taken before and after tests and a short description of previous investigations of fire resisting properties of columns.

Experience and Study Go Hand in Hand

From one viewpoint engineers can be grouped into three classes. There are a few shrewd and competent practical engineers who pay little attention to the published experiences of others and seldom consult books and magazines devoted to their line of work. Their entire store of knowledge, experience and judgment is carried in their heads or is contained in whatever card catalogs, curve sheets, drawings and similar records they have in their offices. On the other hand, there are engineers with the instincts of compilation who are fond of collecting and consulting all kinds of printed information. An engineer of this class may not be able to decide on the best solution in a given case, but he can readily tell what various authorities have advised in similar instances. Both these types are extremes, and neither can be trusted in an important engineering problem involving new features. The third type of engineer, seldom found among the job hunters, is the one who is active in his professional society, who reads at least one leading technical paper regularly and who co-ordinates his practical work with what he reads in new books and periodicals. In other words, a progressive engineer accumulates his own practical experience and judgment on a background of the much more extensive published experience of the leading men engaged in his line of work. In this way he is not apt to generalize from miscellaneous data or be misled by rule-of-thumb methods found useful in his own narrow field, but is more liable to preserve the correct perspective. On the other hand, when his data are confirmed by printed information he feels doubly assured in following the results of his own experience.

Unfortunately, many engineers think that they can find reliable printed information on short notice, without previous training in library search. This is a delusion which sometimes leads to serious disappointment. Only he who follows the current engineering literature more or less regularly can find what he needs with ease and assurance, can assign the proper relative weight to contradictory statements and can be reasonably sure of not having omitted any important reference or clue. Offhand statements on engineering topics are sometimes made on the floor of a convention or in private discussions that are based on old information. They may be the half-baked conclusion of a young enthusiast, they may be the result of honest experience, but experience under special, narrow conditions, or they may be an insidious attempt at advertising a piece of apparatus or some other commodity. It takes long experience to place such statements where they belong, and the only way to gain this experience is to read at least one periodical regularly, so as to be able to analyze every contribution about as quickly and as surely as an editor of long experience and training does. The same consideration, of course, applies to new books.

The critical period in an engineer's career comes soon after he leaves college when he has to shift for himself so far as his mental food is concerned. Then is the time to develop the habit of reading at least one technical magazine regularly, of cutting out and filing useful articles or notes, or following up references to other magazines, of reading book reviews and glancing at publicity pages and advertisements, personnel changes and so forth. Such a practice not only becomes easy later on, but becomes as indispensable a part of one's life as the reading of a daily newspaper. And it may be said without exaggeration that for many a young engineer this choice between reading and not reading a professional journal means in the end the difference between settling down to a narrow routine, with a blind alley at the end, and pursuing a steadily broadening path to varied and satisfying activities.—Editorial in Electrical World.

New Concrete Bridge at Petersboro, Ont., Has 234 Ft. Span

A concrete bridge having a clear span of 234 ft. has been completed recently at Petersboro, Ont. The construction features of this bridge are described in the April 7 issue of the Canadian Engineer, from which the matter following is taken. The bridge connects the residential district east of the Otonabee River with the business district west. It consists of five arches on each side of the river with a central arch ring crossing the river and supporting 10 spandrel arches.

The width of the roadway is 33 ft., the overall width is 47 ft.

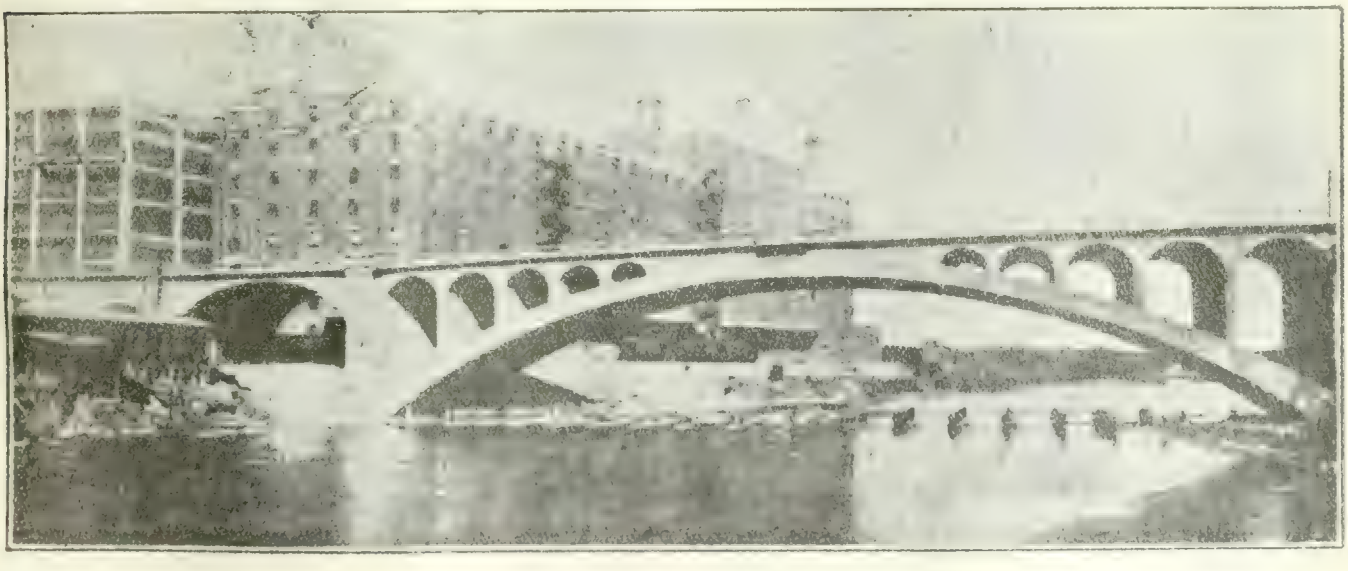
The construction throughout, with the exception of the central or river arch, is of reinforced concrete; with the exception of the joints at the skewbacks and crown there is no steel in the river arch. This arch is so designed that no possible loading can cause any part of the main ring to be in tension at any point. The dead load line of resultant pressure (or more accurately the dead load plus part of the distributed live load) was designed so as to coincide with the neutral axis, which under these conditions is a transformed catenary.

The river arch has a clear span of 234 ft. This is the longest concrete arch in Canada, and the 14th longest in the world.

At each pier, underneath the roadbed, are laid 3-in. weeping tile. These are drained by 5-in. pipes, which have their outlets about 6 in. above ground.

The municipality purchased a gravel pit on the east bank of the river, immediately south of the bridge. A steam shovel was installed and sufficient gravel was obtained to supply all aggregate used on the job, and gravel for the roadway.

A dumping platform was erected at the bridge site, and gravel was teamed onto it. A motor-driven conveyor belt supplied the gravel to a motor-driven rotary screen. All stone over 3 in was rejected and the remainder separated into fine aggregate (up to ¼ in.) and coarse aggregate (¼ in. to 3 in.). From the screen the aggregate dropped into separate bins, which were provided with bottom doors for dumping into the measuring box of the mixer. The mixer was situated immediately beneath the bins, and was fed from the measuring box, which had partitions adjustable for any desired mix. The operator had merely to fill one side of this box from the fine aggregate bin, the other side from the coarse-aggregate bin, add a bag of cement and dump into the mixer.



Ashburnham Bridge, Peterboro, Ont., on March 1, 1921; Hand Rails and Ornamental Lighting Standards Not Yet Placed.

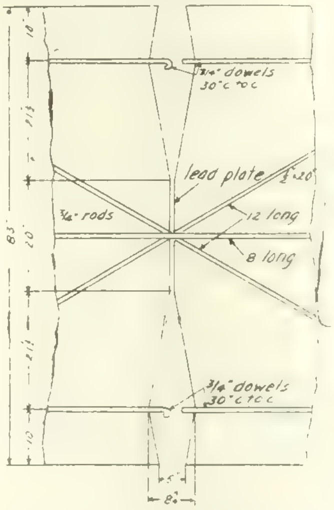
Pit-run gravel was used on all mass work below ground level, but gravel was screened as outlined above for all concrete work above ground. The large stone was used as a base for the roadbed.

For all concrete work up to the spring line of the arches, a 1:3:5 mix was used; above the spring line, a 1:2:4 mix.

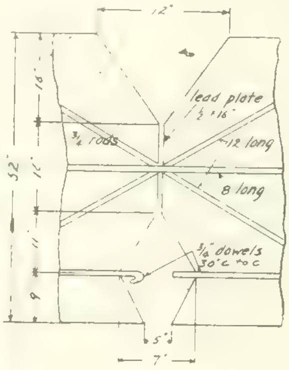
Every effort was made to have the arches approximate their theoretical form as closely as possible. Points on the arches were checked up after completion by means of a level, and in no case were the ordinates as measured by this means in disagreement with the theoretical ordinates by more than a ¼ in.

Mud sills were used to support the centering of the five arches on each side of the river. For the river arch it was necessary to drive piles. The material forming the bed of the river is very hard, but by the use of a 3-ton steam hammer little trouble was experienced in this respect.

Less trouble was experienced in securing satisfactory foundations than is usual in a bridge of this size. No obstacles were encountered that could not be overcome by the use of sheet piling and pumps, and the foundations secured are said to be satisfactory in every respect. The structure rests on very dense hard-pan, with the exception of the foundation on the west bank, where rock was encountered at convenient depth.



Temporary Pivot Joint at Skewbacks of River Arch Bridge.



Temporary Pivot Joint at Crown of River Arch Ring.

Four tons per square foot were used on the foundations. Concrete was placed by means of buggies with a capacity of about 3 cu. ft., using a runway over the formwork. The falsework for the arches remained in position at least 30 days. The wedges were then knocked out and no trouble was experienced in the removal of the centering and falsework.

With the exception of the river span the fill is mostly ordinary surface loam. In order to decrease weight on the arch ring, cinders were largely used for fill on the center circle, a layer of gravel 1 ft. thick being placed over all. The permanent pavement will be constructed when sufficient time has elapsed to permit the fill to consolidate.

Proposed Investigations in Structural Engineering*

By W. M. Wilson

[illegible] Professor of Structural Engineering [illegible]

Structural steel design is largely a mathematical process and is looked upon by many structural engineers as an exact science, nevertheless the mathematic processes are often based upon assumptions which have never been verified, and many of the mathematical operations are nothing more than the solution of empirical equations. Too often these equations lack experimental verification. The changes which are made in specifications from time to time indicate that the consensus of opinion relative to the fundamental assumptions and relative to the empirical relationships are continually changing. Structural engineering is, therefore, not a fixed science, but a science which is rapidly developing.

A study of the discussions which accompany changes in specifications indicates that whereas some revisions are the direct and inevitable result of additional scientifically established facts, other revisons grow out of a change in what is nothing more nor less than the opinon of the structural engineers. Although this opinion may be entertained by the leaders in the profession, as long as scientific confirmation is lacking, the opinion is liable to further change with additional experience. It is therefore highly important that all basic assumptions and all empirical relationships be checked by scientific experimental work.

It is believed that certain problems in structural engineering should receive further experimental study. In presenting these problems the position is taken, not that our present practice is necessarily wrong, but that we have not sufficient knowledge to justify us in forming a final and definite conclusion.

The following are a few of the many problems which affect either the cost or the safety of the structures.

Effect of Reversed Stresses on Riveted Joints.—Tests of riveted joints show that the resistance to slip is due to friction between the plates induced by the tension in the rivets. Moreover this slip, an inelastic strain, occurs at stresses considerably below the stresses for which connections are designed. These statements being true, if a stress on a connection acts in one direction there will be a slip in that direction; and if the stress is reversed, the slip is in the reversed direction. By repeating the cycle, the repeated slip will result in wear which relieves the tension on the rivet and thus reduces the resistance to slip. Therefore a large number of reversals may result in an amount of wear which will permit a small stress to produce a large slip.

That the action outlined does take place is evidenced by the fact that connections of members subjected to reversed stresses do work loose. This has been observed in a number of structures.

To further establish the action outlined, a few tests were made to determine the effect of repeatedly reversed stresses (unpublished tests made at the Engineering Experiment Station of the University of Illinois by W. M. Wilson). These tests show that connections subjected to reversed stresses, if designed in strict accordance with our present specifications, may be expected to develop loose rivets. This being true, changes in the usual specifications should be considered. But before the specifications can be changed intelligently, more complete knowledge relative to the behavior of riveted connections subjected to reversed stresses is needed. Experimental data are desired to answer the following questions:

1. What is the proper unit stress to be used in designing a rivet subjected to reversed stresses?

2. What is the relative value, as judged by their ability to resist reversed stresses, of rivets driven by different methods?

3. Is it possible to develop a method of driving which will increase the ability of rivets to resist reversed stresses?

Because of the increase in the weight of rolling stock, railroads are compelled to subject their bridges to stresses considerably greater than the stresses for which the bridges were designed. Following the recommendations of the American Railway Engineering Association, the stress in tension for rating old bridges made of openhearth structural steel is 26,000 lb. per square inch, while the corresponding stress in shear on rivets is 22,000 lb. per square inch. In both cases the allowable stresses are reduced if the stresses are reversed; the reduced stress for tension on steel is 17,333 lb. per square inch, and for shear on the rivets is 11,000 lb. per square inch, if the reversal is from a stress in one direction to an equal stress in the opposite direction.

Fatigue of metal tests indicate that a tensile stress in steel considerably greater than 17,333 lb. per square inch can be reversed millions of times without breaking the metal, whereas tests indicate that if a shear on rivets of 11,000 lb. per square inch is reversed only a few thousand times, the rivets are loosened. It therefore seems probable that overloading bridges will injure the bridge, not by injuring the metal, but by loosening the rivets. This being true, an extended investigation of the behavior of riveted joints subjected to reversed stresses assumes unusual importance.

A Comparison of Various Types of Wind Bracing for Steel-Skeleton Buildings.—The usual method of stiffening the frame of a steel-skeleton building so that it will resist wind pressure, is to make the joints connecting the girders and columns rigid, so that they can resist moment. Two types of connections are in general use. With one type, in order to erect the girders, it is necessary to slip the gusset plate, a part of the column, between the flange angles of the girder. As this operation takes place high in the air, the erection is quite difficult. With the other type, erection is accomplished by swinging the girder between two adjacent columns, and riveting the outstanding legs of the connection angles to the outstanding legs of the column, a very simple process. In spite of the fact that the first type is much harder to erect than the second, the former is replacing the latter, as it is believed to be more rigid. A very limited number of tests (Bulletin No. 104, Engineering Experiment Station, University of Illinois, by Wilson and Moore) show that there is but little difference between the rigidities of the two types of connections; and that, if there is any difference, the second is slightly stiffer and therefore better than the connection of the first type. It is desirable to determine definitely the relative merits of these two, and also of other types of connections.

Distribution of Stresses Among Rivets of Large Gusset Plates.—In designing a riveted connection which is not subjected to moment, it is assumed that the total stress on the connection is equally distributed among the rivets. Gusset plates are usually much wider than the members from which they receive stress. Under these circumstances, it seems probable that the stress in the rivets in a line with the axis of the member may be greater than in the rivets near the edges of the gusset plate.

In riveted joints, as in elastic material, the stress is approximately proportional to the strain. Because of the difference in stresses in theg usset plate and in the member, the slip, the relative motion between the two, may not be the same at all points. As the stress depends upon the slip, a variation in the slip will cause an uneven distribution of the stress among the rivets.

A limited number of tests by Cyril Batho (Journal Franklin Institute, Vol. 182, page 553) indicate that the stress on a joint is not evenly distributed among the rivets. The maximum stress will, therefore, be greater than the total stress divided by the total number of rivets, as now assumed. A thorough investigation of the distribution of stress among rivets is desirable.

Effect of Restraining Action of End Connections Upon Stringers of Through Truss Bridges.—The stringers of through trusses are connected to the floor beams by means of connection-angles which run the full depth of the stringers. Tests show (Bulletin No. 104, Engineering Experiment Station, University of Illinois, by Wilson and Moore) that these connections are quite rigid. This being true, two stringers meeting end to end act as a continuous girder. While this action reduces the moment at the center of the stringer, it also produces a large, suddenly applied moment on the stringer connection. And the stringer connection is not designed to take moment. It is desirable to determine the moment on the connection-angles and, if it is found to be dangerous, to devise alternate possibilities of design.

Effect of Not Fitting Ends of Intermediate Stiffness of Plate Girders to Outstanding Legs of Flange Angles.—Stiffeners of plate girders are fitted carefully to the flange angles. This involves grinding the ends of the stiffener angles to exact length and shape, and involves either the use of thick fills or of crimping the angles. Taken altogether this fitting adds materially to the cost of the girder.

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*[illegible] Mr. [illegible]

The function of intermediate stiffeners is to prevent the web from buckling. The stiffener does not in any sense transfer stress to or from the flange angles. It would therefore seem that the requirement that the ends of intermediate stiffeners be ground to fit the outstanding legs of the flange angles is without a rational basis. It is desirable to make tests to verify this statement.

Mathematical Study of Secondary Stresses.—The exact theoretical determination of secondary stresses is a very laborious process. This is true to such an extent that secondary stresses are neglected except for very important structures, in spite of the fact that it is known that, theoretically at least, secondary stresses are often almost as great as primary stresses. It is desirable to make a careful study of secondary stresses with the idea in mind of establishing empirical rules for determining secondary stresses. These rules should be accurate enough for purposes of design and should also be so short that they will be used by the practicing engineer. Such rules have been established for wind stresses in steel skeleton buildings (Bulletin No. 80, Engineering Experiment Station, University of Illinois, by Wilson and Moore), and it should be possible to establish them for secondary stresses in trusses.

Experimental Study of Secondary Stresses.—To a large extent, secondary stresses have been neglected by practicing engineers. The engineer has justified his action by the statement that secondary stresses are small, or that the determination of secondary stresses is based upon false assumptions, and that large secondary stresses do not exist.

Inasmuch as computed secondary stresses are often very large, they should not be neglected, if they actually exist; and if they do not exist, the ghost should be laid. A limited number of tests show that secondary stresses do exist, and that the measured and computed stresses agree quite well. Tests by Parcel and Maney (Engineering News-Record, Dec. 9, 1920, p. 1116), show a secondary stress equal to 85 per cent of the primary stress at a time when the primary stress is a maximum. Further experimental data are desirable.

Effect of Elongation and Compression of Bottom Chord Upon Streses in Floor System of a Through Truss Bridge.—The stress in the bottom chord of a truss is a maximum at all points when the whole span is loaded. This being true the entire bottom chord can be subjected to a maximum stress at the same time. The elongation due to live load and impact stresses from the center to the end of a 200-ft. truss is approximately ½ in. If therefore the floor system is erected with no live load on the span, the passing of a full live load over the bridge will produce a horizontal deflection in the end floor beams of ½ in., a strain that is neglected in the design of the bridge. The bending of a floor beam also produces a horizontal shearing stress on the floor beam connection angles which is not considered in the design. Straingage measurements taken on bridges under actual conditions of service disclosed stresses very much in excess of the stresses produces by the vertical load on the floor beams alone.

Why a More Exact Knowledge of the Behavior of Structures Is Desirable.—Research work necessary to answer the questions which have been raised is expensive. Moreover, a more exact analysis of stresses in structures would probably require better trained designers and would probably require that more time be spent on the design of structures than is now customary. Both of these changes increase the cost of a design. The question is often raised, why is it necessary to incur this expense for research since our present designs are proving satisfactory in service? To accept the line of reasoning implied by this question is to accept the design of the ancients as the acme of structural science as these structures have stood through the centuries. To accept the line of reasoning implied by this question is also to eliminate economy as a controlling factor in an engineer's work.

All structures are designed with a factor of safety. That is, every member is made strong enough to carry a load greater than any load to which it is likely to be subjected. The magnitude of this factor of safety varies through a wide range. The fact that a structure has not failed in service is proof, not that the design is properly balanced, but that in trying to provide a factor of safety of from 2 to 5 the designer has succeeded in providing a factor of safety of at least one in each and every member.

If a designer were to specify a tension member having a cross-sectional area of 20 sq. in. at one end and a cross-sectional area of 30 sq. in. at the other end the design would be ludicrous. Such an evident lack of balance in the design would be ridiculous. Yet the only offense which the designer has committed has been to provide a factor of safety of three at one point and a factor of safety of two at another point in the same structure.

Tension members are usually designed for a primary unit stress of 16,000 lb. per square inch. Some tension members are subjected to practically no secondary stress while others have secondary stresses equal to 50 per cent of the primary stresses when the primary stresses are a maximum. This being true, the member which is not subjected to secondary stresses has a factor of safety 50 per cent greater than the factor of safety in the member subjected to the secondary stresses. That is, the neglect of secondary stresses results in structures which are as badly unbalanced in design as a tension member having a sectional area 50 per cent greater at one end than at the other. There is, however, this difference. The fact that the design in unbalanced is self evident in the one case, but is concealed by a misleading statement of the stresses in the other case. It is like two thieves of whom one is caught while the other escapes. One is counted a thief and the other is not, but they are both equally guilty.

The object of the designer should be to produce a balanced design. That is, all members of equal strategic value should have equal factors of safety. If all but one of a number of members of equal importance have a factor of safety of three, while the one member has a factor of safety of two, the material in the others in excess of that necessary to give them a factor of safety of two is wasted. And this waste is chargeable to poor design.

I have heard the statement made that so long as engineers receive as a fee a certain per cent of the cost of the structure they will not reduce the cost at increased expense to themselves by making more careful designs. This position is comparable to the position taken by a physician who would advocate halting all medical research, as more perfect knowledge would result in better health for the community and less fees for the doctor.

Engineers bemoan the fact that their profession is unremunerative. Yet they continue to design with a handbook and to a great extent refuse to give special problems the study which they deserve. The very fact that they accept handbook design makes it necessary for them to compete with handbook artists who do not understand the principles involved in the formulas which they use, and who make no pretense at having a professional training. Many of these handbook designers are not professional men in any sense of the word. They should be classed as mechanics. Yet so long as we are content with handbook designs we will have to compete with the handbook artist.

Many designers do not realize the source of the information which handbooks contain nor do they realize how the requirements contained in specifications are established. The well founded equations and requirements of the specifications are based upon research work of the past. Methods of design which are still in a state of flux require research work for their final determination.

I believe that what is usually known as af actor of safety should be considered as the product of two factors, one a true factor of safety, and the other a factor of ignorance. The work of our scientists has made it possible to manufacture steel whose physical properties will not vary more than 5 per cent to 10 per cent from the standard desired. This being true, if we have a steel whose elastic limit is 32,000 lb. per square inch and whose ultimate strength is 64,000 lb. per square inch, it certainly would be safe to deliberately plan on subjecting this steel to a stress of 24,000 lb. per square inch, providing we were absolutely sure that 24,000 lb. per square inch is the maximum stress to which the member will ever be subjected. The ration $\frac{32000}{24000} = 1.33$ (or $\frac{64000}{24000} = 2.66$ if the factor is based upon the ultimate strength instead of upon the elastic limit) is a true factor of safety. But because we are not sure just what load the member will be required to carry, we design for a stress of 16,000 lb. per square inch. The factor $\frac{24000}{16000} = 1.5$ is not in the true [illegible] a factor of safety, but is in reality [illegible] ignorance. We are afraid that the stress which [illegible] will be 16,000 lb. per square inch, may be 24,000 lb. [illegible]. This factor of ignorance is a measure of the amount by which the working stress is reduced and a measure of the amount of material wasted because of a lack of knowledge of the exact stress to which a member will be subjected.

The factor of ignorance covers a lack of knowledge of the exact value of the maximum load to which the structure is subjected, and also covers our inability or our unwillingness, to make an exact analysis of the stresses due to a given load. Ignorance as to the maximum value of the load in many cases cannot be eliminated; but ignorance as to the stress resulting from a given load can at least be reduced if not, in fact, entirely eliminated. The elimination of one contributing part of the fact of ignorance should justify a reduction in the factor itself, and should justify the use of higher working stresses than are now permitted.

For the benefit of those who object to increasing our present working stresses where more exact analyses are used, let me call attention to the fact that scientists who are experienced in testing materials find that it is impossible to injure structural steel with a tensile stress of 24,000 lb. per square inch. In the few cases where steel structures have failed, the failure has not been because the true factor of safety was too small, but because the factor of ignorance was too small. In fact, in the case of most of the failures, the ignorance on the part of the designer was so collossal that no factor could be depended upon to offset its effect. I believe that more care in stress analysis and increased knowledge of the behavior of structures subjected to load will promote economy and safety simultaneously.

How Structural Research Can Be Promoted.—There are two interested parties in every contract for a steel structure, the manufacturer who furnishes the material and the owner who pays the bill. The manufacturer wants the structure designed so that it will be easy to manufacture and, if it is a lump sum contract, he is interested in light weights. But he knows that if the structure fails his reputation will suffer. The owner having once signed the contract wants the best bridge that he can get. But he knows that if his specifications are unreasonable he will have to pay an exorbitant price. So that while the interests of the two parties at first glance seem to conflict, they really are in harmony. Both want the lightest possible bridge that will safely carry the load. Both will be financially benefited by the development of this ideal structure.

Although manufacturers and owners will both be benefited by the development of an ideal design they are both human, and neither is always willing to believe that changes suggested by the other are for their mutual benefit. The owner is likely to question innovations in shop practice, believing them to be the product of a desire to cut shop costs rather than to increase strength. Likewise the manufacturer may consider that changes suggested by the owner increase the cost more than they increase the quality.

It therefore seems apparent that any research work which might result in changes in design or manufacture should be conducted by a disinterested party. This is necessary in order that the results may be accepted without prejudice by both parties. Furthermore, scientific investigations require long continued painstaking efforts. Both of these requirements point to our scientific organizations such as the Bureau of Standards and the Engineering Experiment Stations as the proper agents to undertake this work.

The scientific organizations have the men trained in scientific work and have the equipment but they cannot undertake any extensive series of tests because of a lack of funds. However, inasmuch as both the manufacturer and the owner will be benefited financially by the development of the design and manufacture of steel structures, it is not unreasonable to ask them to help the scientific organizations finance the investigations.

The railroads are and always will be in the market for steel structures. They probably have a greater interest in the development of structural enginering than any other single class of users. They are interested in more exact knowledge of stress distribution and they are interested in more exact knowledge of the relative merits of various shop methods. Moreover, their interest is not scientific alone, but economic as well. If additional knowledge will give them as good bridges at less cost, or better bridges at the same cost, they are justified in spending money to gain this knowledge.

The knowledge to be gained by the suggested tests to determine the effect of reversed stresses on rivets, will, I am sure, help the railroads to keep their old bridges in service under the present increasing loads. This saving will exceed the cost of the research program necessary to obtain the knowledge required.

The manufacturers will also be financially benefited by the elimination of unnecessary shop refinements which add but little or nothing to the quality of the structure but which add materially to the cost of production.

I believe that it is possible to establish a scheme of cooperation whereby the manufacturers and the users of structural steel, especially the railroads, will co-operate with the scientific organizations of the country to the end that extensive research work in structural engineering can be undertaken The part of the scientific institution will be to furnish the scientific staff, laboratories, and standard equipment, and to publish the results. The part of the manufacturers and users of the structural steel will be to furnish the material to be tested and to furnish money to pay for special equipment and technical assistants. The engineering staffs of the commercial organizations will also be expected to consult with the scientific staffs in planning the investigations.

I believe that such a scheme of co-operation will be beneficial to all parties concerned.

Precedent for this co-operation has already been established at the University of Illinois. The Engineering Experiment Station of the University is or has been a partner in the following investigations:

Investigation of Coal Mining in Illinois.

Investigation of the Manufacture of Gas from Illinois Coal.

Investigation of the Stresses in Railway Track.

Investigation of the Effect of the Size of Coal on Locomotive Performance.

Investigation of Warm Air Furnaces and Furnace Heating.

Investigation of the Fatigue Phenomena of Metals.

Investigation of the Viscosity and Electrical Conductivity of Glass.

Investigation of the Friction Losses and Power Requirements in the Proposed Ventilating System for the New York and New Jersey Vehicular Tunnel to Be Constructed Under the Hudson River.

These co-operative tests have been financed from sources outside of the Engineering Experiment Station to the extent of approximately $340,000. And in every case the parties contributing the funds have felt that the value received exceeded the funds expended.

A similar program of co-operative research is desirable in structural engineering.

How to Prevent Falls of Workmen in Building Construction.—In the May National Safety News, Mr. Leo D. Woedtke, manager protection and safety department, Fred T. Ley & Co., Inc., contractors, summarizes as follows the methods employed by that company for preventing accidental falls by its workmen: Superintendents are instructed to see that all floor openings and elevator shafts are covered with planking or barricaded with substantial railings; that all stagings, scaffolds, platforms, runways, and stairways are built of sound lumber and equipped with strong railings; that the aforementioned are never overloaded; that all passageways are clear, that debris is always piled in out-of-the-way places, that ladders are never painted with pigment paint or lead, as these cover up defects—linseed oil and shellac should be used; and that no patched or unsafe ladders are used.

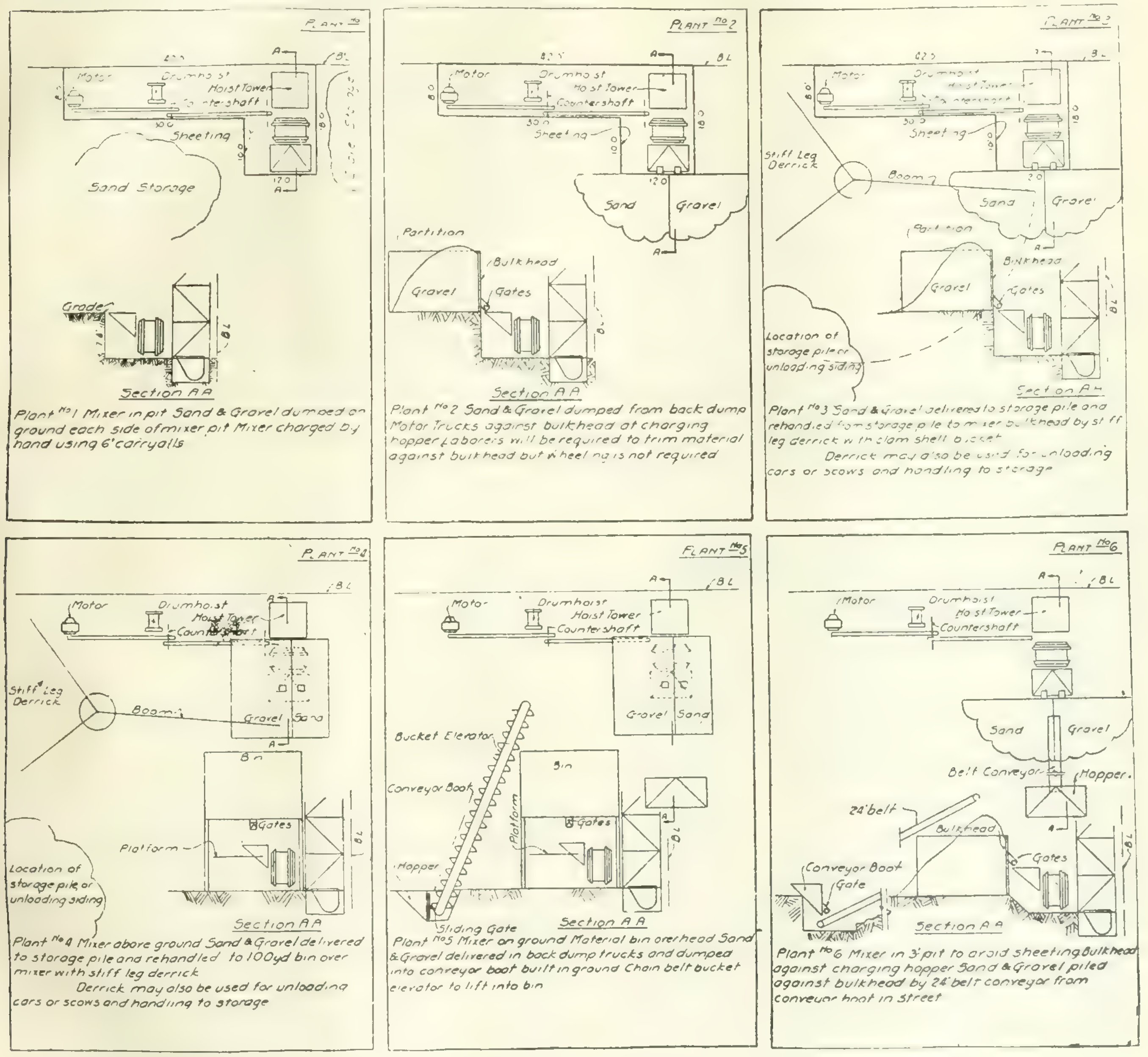
Examination for Junior Civil Engineer, U. S. Bureau of Public Roads.—The U. S. Civil Service Commission, Washington, D. C., announces an open competitive examination for junior civil engineer to fill vacancies in the Bureau of Public Roads, at an entrance salary of $1,500 a year. The duties of the position will be to assist in the survey and construction of roads of various types throughout the United States, to assist in the review of plans, specifications, and estimates for roads and bridges, to prepare estimates and statistical tables and charts, to assist in testing laboratory on tests of materials and in highway research, and to assist in the field extension work of the Bureau of Public Roads. Applications must be filed before June 14.

Plant Layouts for Reinforced Concrete Construction

Contractor's Plant was the subject of a report presented to the American Concrete Institute Convention by its Committee on Contractor's Plant in Reinforced Concrete Construction. The report was printed in Concrete, from which the following abstract is taken.

The study of the operations of unloading and transporting was omitted from the report.

The plant depends on a number of conditions peculiar to each job. Of the great variety of plant arrangements possible, most were grouped into seven fundamental arrangements, differing from an elementary plant by the addition of labor-saving equipment.



Plant No 1 Mixer in pit Sand & Gravel dumped on ground each side of mixer pit Mixer charged by hand using 6' carryalls

Plant No 2 Sand & Gravel dumped from back dump Motor Trucks against bulkhead at charging hopper Laborers will be required to trim material against bulkhead but wheeling is not required

Plant No 3 Sand & Gravel delivered to storage pile and rehandled from storage pile to mixer bulkhead by stiff leg derrick with clam shell bucket
Derrick may also be used for unloading cars or scows and handling to storage

Plant No 4 Mixer above ground Sand & Gravel delivered to storage pile and rehandled to 100 yd bin over mixer with stiff leg derrick
Derrick may also be used for unloading cars or scows and handling to storage

Plant No 5 Mixer on ground Material bin overhead Sand & Gravel delivered in back dump trucks and dumped into conveyor boot built in ground Chain belt bucket elevator to lift into bin

Plant No 6 Mixer in 3' pit to avoid sheeting Bulkhead against charging hopper Sand & Gravel piled against bulkhead by 24" belt conveyor from conveyor boot in street

Six Fundamental Arrangements of Plant Used for a Comparison of the Costs of Placing Concrete.

The problem of contractor's plant is to determine a layout in which the cost of extra equipment will not overbalance the money saved in labor. It is suggested to plot the operating costs, cost of installing and depreciation or rental of plant in form of charts. These charts based upon general assumption will make it possible to estimate the costs of various plants. Any contractor may plot a set of curves based on his layouts.

For the purpose of illustration the seven fundamental arrangements were analyzed in the report. It has been taken for granted that on jobs of less than 3,000 yd. a ¾-yd. plant would be used, with 50-ft. wood tower, 8 carryalls for placing and 300 ft. of run panels assumed as the average equipment. Jobs over 3,000 yd. would have a 1-yd. plant, wood tower averaging 125 ft., 12 carryalls for placing and 400 ft. of run panels. As many contractors standardize on 1-yd. chuting equipment, this has been used for both ¾-yd. and 1-yd. plants, but with a 100-ft. steel tower for the ¾-yd. and a 180-ft. steel tower for the 1-yd. plants.

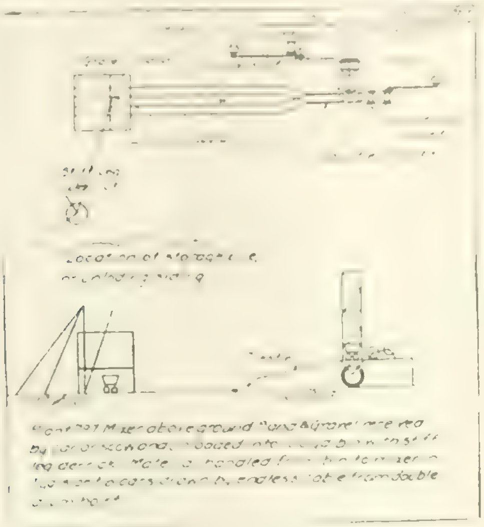
These assumptions are for an average of several conditions.

For a job of medium size the difference in cost of plant per cubic yard of concrete would be very slight as compared with the total cost. But on a large job a difference in cost per cubic yard would warrant an investigation of each plant layout.

The curves plotted for the seven layouts are shown in the accompanying diagram. To illustrate the application of the charts the committee assumed the following case: A building containing 15,000 yd. of concrete, for which it is desirable to use two mixing plants. Choice is between plants of types No. 3 and No. 4 where the contractor loads the material and a plant similar to No. 5 for which the material is delivered by a dealer.

It is assumed that yardages handled by two plants are approximately equal and comparison was made on the basis of 7,500 yd. per mixer. On comparing first plants No. 3 and No. 4 it is found that the costs per yard for plant and installation were respectively $0.76 and $0.70. The combined cost for [illegible] tallation and operation wa[illegible] nd [illegible] Choice is therefore between No. [illegible] which show[illegible] total of $2.62, or 13 ct. per [illegible]

To these figures must however, be [illegible] charges for No. 4 and unloading and trucking for No. 5. These figures will ordinarily run about 20 ct. for No. 4, and 50 ct. for No. 5, assuming a mile haul and disregarding dealers' profit on the transaction. The revised figures stand as follows:

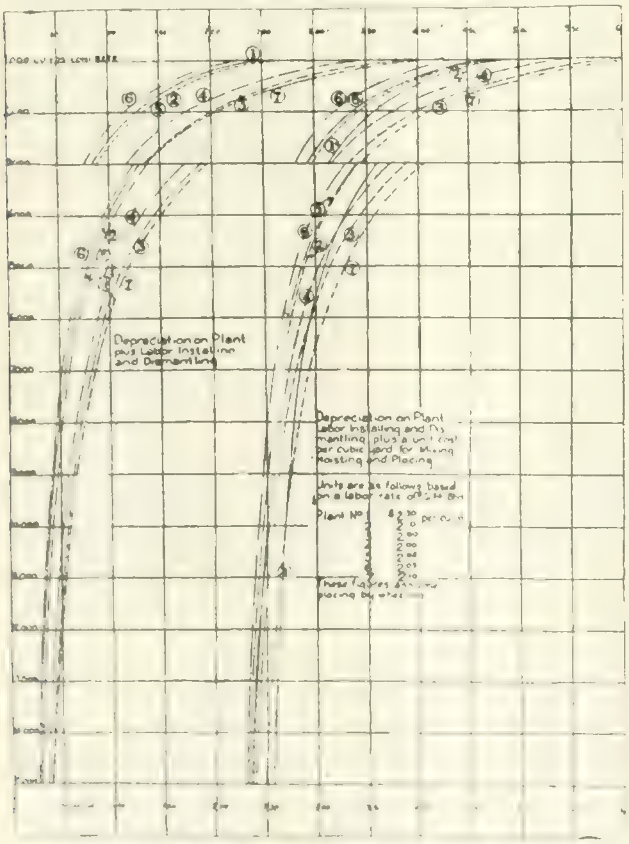


A Seventh Arrangement of Plant.

No. 4—Plant, Installation and Operation, 2.75 + 20 = $2.95

No. 5—Plant, Installation and Operation, 2.62 + 50 = $3.12

If the contractor has chuting equipment he will refer to a chart which is a comparison between placing by wheeling and chuting. It will be found that at 7,500 yd. while the chuting equipment will cost 11 ct. more per yard in plant charges, it will save 40 ct. net on the combined total of plant installation and operation. The additional plant charge for chuting equipment is therefore justified by the saving in labor charges.



Comparison of Seven Types of Plant Layout.

Any job can be analyzed in a similar manner. Outlining the arrangements possible under the conditions met with on the job, the contractor can get at the unit cost by means of charts.

In conclusion the committee states:

1. While no recommendations can be made for a standard plant layout to meet all conditions, the layouts which have been found best adapted to average concrete building construction can be classified as modifications of a few fundamental types.

2. Elaborate plant is not justified on the mere statement that it saves labor. Analysis is required to prove that the elaborate plant used will be an ultimate saving. Such analysis for the determination of the cost of installation and operation per cubic yard are best made with the help of charts drawn up by the contractor from his own records. By means of these analyses it will be possible to tell whether a proposed plant layout will be the cheapest when all items of cost are considered.

Accidents to Structural Iron Workers

An industrial accident report issued recently by Local Union No. 1 (Chicago) of the Bridge and Structural Iron Workers contains some interesting information on the frequency and cause of accidents in that trade. According to the report 134 members of the local, or 14.62 per cent of the total membership, sustained injuries in 1919. The average duration of disability was 5 weeks and 1 day. The causes of accident in 1919 were as follows:

	No.	Per cent.
Slipped and fell	32	23.90
Caught in machinery or material	31	23.00
Struck by machinery or falling objects	21	15.70
Defective scaffold or machinery	21	15.70
By own tools, slipped or broken	11	.20
Steam, cinder, soot, sand and water	5	3.80
Stepped on rusty nail	9	6.70
Froze fingers	1	0.75
Falling wall	1	0.75
Bruised	1	0.75
Jumped in self-protection	1	0.75
Total	134	100.00

The nature of employment when the accident occurred was as follows:

Connecting	17
Riveting	17
Moving material	13
Moving tools or machinery	11
Rod work	10
Loading and unloading	10
Derrick men	11
Chutes and cables	9
Diverse classifications	7
Drilling holes	6
Raising gang	6
Foremen	5
Fitting up	4
Wrecking	4
Shoring up	2
Setting grillage	1
Signal men	1
Total	134

The following table shows the days on which accidents occurred:

	January-June.		July-December.			
	No.	Per cent.	No.	Per cent.	Total.	Per cent.
Sunday	1	[illegible]	1	1.50	2	1.45
Monday	19	[illegible]	13	20.00	32	23.80
Tuesday	11	[illegible]	13	20.00	24	18.00
Wednesday	5	[illegible]	12	18.40	27	12.80
Thursday	9	[illegible]	10	15.40	19	14.20
Friday	9	[illegible]	10	15.40	19	14.20
Saturday	15	[illegible]	6	9.30	21	15.55
Total	69	100.00	65	100.00	134	100.00

Strength Tests of Ideal Brick Walls.—An investigation has been started by the U. S. Bureau of Standards to determine the compressive strength of ideal brick walls in cooperation with the Common Brick Manufacturers' Association of America. The ideal walls are laid with common brick, but in such a manner as to include an air space in the wall and still be well tied together. There is a considerable saving in the number of bricks, the amount of mortar and the time required to lay these walls over the ordinary solid walls. It is also claimed that one can plaster directly on these walls thus avoiding the expense of studding, lath, etc. The present schedule calls for the erection of three Ideal walls and two solid ones for comparison. Four of the walls have already been built and will be tested as soon as they are 30 days' old. Considerable preliminary work, such as gage calibration and the testing of individual bricks, has already been done.

Building Values, Material Prices and Rates of Wages*

By W. N. PATTEN.

The factor that determines whether or not a building can be constructed is, in most instances, the rate of return that can be obtained for the money invested, and this holds true for a residence built solely for the owner's occupancy, as well as for rentable property. In the one case, the owner must be able to build at such a cost that fixed charges, interest, taxes, insurance, repairs and upkeep will not exceed a reasonable rental charge, and in the second case, the owner must be able to obtain a fair return on investment. Buildings constructed at high cost must compete with buildings built at lower cost in preceding years and also with buildings which may, and probably will, be built at lower cost in succeeding years. All costs are relative, in that a level of prices as established for the period prior to the war may not necessarily be the level at which we shall reach a period of stability in the future.

The theory that action is equal to reaction apparently does not hold true in the case of construction costs, as statistics show that with each succeeding wave of high costs, the dip has never been quite as low as the preceding one. Building costs were reasonably stationary during the two or three years preceding the war and increased sharply early in 1916 when the facilities of this country were called into play to supply the needs of the great armies of Europe. This called for great expansion of industrial concerns, added capacity of public utilities, and increase in community housing by many industrial concerns who found it necessary to provide accommodations for their rapidly growing forces. The demand for materials and the sharp rivalry of concerns operating along similar lines caused a decided increase in prices, to which was added the increase in labor rates, due, as in the case of material, to the sharp demand and the bidding for labor at constantly increasing rates. The increase continued after the entrance of our own country into the war, and no doubt would have risen still higher but for restrictions placed on private building operations by the government. A temporary halt in prices occurred after the armistice of Nov. 11, 1918, to be followed six to eight months later by expansion of many industrial concerns in their feverish anxiety to be ready for the great wave of prosperity which appeared to be sweeping the country. Again the demand for structural materials outstripped the supply and available stocks were soon depleted. Labor ran neck and neck with the increasing cost of material until the peak of rising prices was reached in the early part of 1920. The result of this pyramiding of prices was inevitable, as construction costs were reaching proportions at which fair returns could not be obtained and the exigencies of the wartime demand no longer warranted construction at exorbitant figures.

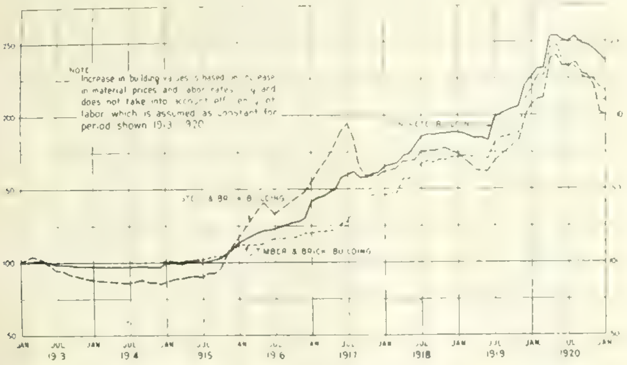


Fig. 1—Fluctuation of Values of Three Types of Buildings in Boston, Using 1913 Value as 100.

It is possible to indicate by graphical charts the rate of increase in construction costs as affected by increases in the price of materials and labor, but it is difficult to ascertain the factor of efficiency which determines whether or not labor gives a normal output for its day's pay.

It will hardly be questioned that activity in the building trades carried beyond the point of labor saturation or where there are more jobs than there are men to fill them creates a restlessness on the part of labor and a consequent slowing of production, and that conversely an oversupply of labor tends towards competition and gives the workman an incentive to keep his output up to normal. Opinions differ as to the effect of this factor on the cost of construction, but fundamentally the fact cannot be denied that a man in any occupation will do more effective work when two or three men are ready to step into his place than when his services are in demand from several sources.

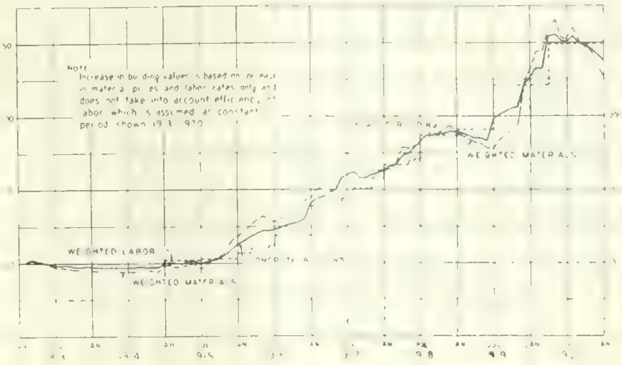


Fig. 2—Fluctuation of Values of Combined Weighted Material and Labor in Boston Concrete Building, Using 1913 Value as 100. Weights Are Based on Actual Percentage of Cost of Each Material to Actual Total Cost of Building.

Chart No. 1 (Fig. 1) indicates the fluctuation in value of three types of buildings for the period from Jan. 1, 1913, to Jan. 1, 1921, determined by taking actual cost records in 1913 and increasing those values in proportion to the increases in wage rates and material costs.

Chart No. 2 (Fig. 2) indicates the increase in value of a concrete building for the same period and shows that labor costs increased almost in the same proportion as material costs.

The factor of efficiency is not considered in making up the charts, owing to the difficulty of definitely determining the variation in output during the period under consideration, and it is assumed that labor efficiency has remained the same. The peak of the curve of Chart No. 1 extends two and one-half times above the 1913 value; but if it were possible to measure accurately the productivity of labor for the past six years, it would be found that the actual cost of constructing buildings during the past year would be more than three times the pre-war cost.

Chart No. 3 (Fig. 3) shows increase in the average rates of wages for twenty-two representative trades in the construction industry for the period between July, 1913, and Jan. 1, 1921, for the cities of San Francisco, Galveston, New York, Pittsburgh, Boston and Cincinnati.

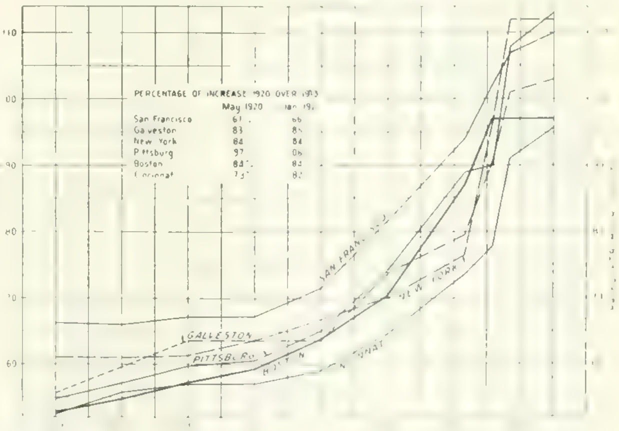


Fig. 3—Average Rates of Wages in 22 Building Trades in Cities Shown, Compiled From Schedule of Chicago Builders' Association.

Charts 1 and 2 indicate the downward trend of material prices and its effect on the cost of building construction.

That we may expect much greater reductions in the prices of construction materials, without recessions on the part of labor, seems improbable, as labor constitutes such a large percentage of the cost of manufactured products and enters

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*From Stone & Webster Journal.

[illegible] largely into the cost of fuel and the transportation of construction material. The law of supply and demand must inevitably act to remedy the present industrial stagnation, for labor cannot long remain idle and capital must of necessity be made productive if industry is to survive and our great nation is to keep up its march of progress.

Index Numbers of Wholesale Prices 1913 to April 1921

The accompanying tabulation shows the index numbers of wholesale prices by groups of commodities, as computed by the U. S. Bureau of Labor Statistics. The group of miscellaneous commodities includes such important articles as cottonseed meal and oil, lubricating oil, [illegible], newsprint and wrapping paper, rope, soap, laundry starch, tobacco, Manilla hemp, sisal, phosphate rock and wood pulp. The commodities, including the other groups, are as indicated by the title:

INDEX NUMBERS OF WHOLESALE PRICES IN SPECIFIED YEARS AND MONTHS, 1913 TO APRIL, 1921, BY GROUPS OF COMMODITIES.
(1913—100.)

Year and month	Farm products	Food, etc.	Cloths and clothing	Fuel and lighting	Metals and metal products	Building materials	Chemicals and drugs	House furnishing goods	Miscellaneous	All commodities
1913	100	100	100	100	100	100	100	100	100	100
Jan.	[illegible]	[illegible]	100	[illegible]	[illegible]	[illegible]	101	100	100	100
April	97	96	100	98	102	101	101	100	98	98
July	101	[illegible]	[illegible]	99	[illegible]	101	[illegible]	100	101	100
Oct.	[illegible]	102	100	[illegible]	[illegible]	[illegible]	100	[illegible]	100	101
1914	[illegible]	103	98	96	[illegible]	[illegible]	101	[illegible]	[illegible]	100
Jan.	101	102	98	99	[illegible]	98	100	99	99	100
April	103	[illegible]	[illegible]	98	91	[illegible]	[illegible]	99	101	98
July	104	104	99	95	[illegible]	97	[illegible]	[illegible]	97	100
Oct.	[illegible]	107	97	93	[illegible]	96	105	99	96	99
1915	105	104	100	93	[illegible]	[illegible]	114	[illegible]	99	101
Jan.	102	106	96	93	[illegible]	[illegible]	103	[illegible]	100	99
April	107	105	99	89	91	94	102	99	99	100
July	108	104	99	90	102	[illegible]	108	[illegible]	98	101
Oct.	105	103	103	90	100	[illegible]	124	[illegible]	99	101
1916	122	126	128	119	148	101	[illegible]	115	120	124
Jan.	108	113	110	105	126	[illegible]	150	105	107	110
April	114	117	119	108	147	101	152	108	110	117
July	118	121	126	108	145	99	[illegible]	121	120	119
Oct.	136	[illegible]	138	133	[illegible]	101	150	124	132	134
1917	189	176	181	175	208	124	198	144	155	176
Jan.	148	150	161	176	183	106	159	132	138	151
April	181	182	[illegible]	184	208	114	[illegible]	139	149	172
July	199	181	187	192	[illegible]	[illegible]	198	152	153	186
Oct.	208	[illegible]	193	146	182	[illegible]	[illegible]	152	163	181
1918	220	189	239	163	181	[illegible]	[illegible]	196	193	196
Jan.	207	187	211	157	[illegible]	[illegible]	[illegible]	161	178	185
Feb.	208	186	216	157	[illegible]	[illegible]	[illegible]	161	181	186
March	212	177	223	158	[illegible]	144	[illegible]	165	184	187
April	217	178	232	157	[illegible]	[illegible]	[illegible]	172	191	190
May	211	[illegible]	[illegible]	160	[illegible]	[illegible]	[illegible]	173	194	[illegible]
June	217	179	245	159	[illegible]	[illegible]	[illegible]	[illegible]	196	193
July	[illegible]	184	249	166	[illegible]	154	[illegible]	[illegible]	190	198
Aug.	230	191	[illegible]	166	[illegible]	[illegible]	[illegible]	221	[illegible]	202
Sept.	[illegible]	[illegible]	[illegible]	[illegible]	184	[illegible]	[illegible]	226	194	207
Oct.	[illegible]	201	[illegible]	[illegible]	187	[illegible]	[illegible]	226	196	204
Nov.	221	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	203	206
Dec.	222	210	[illegible]	171	184	[illegible]	[illegible]	[illegible]	204	206
1919	[illegible]	[illegible]	[illegible]	[illegible]	161	[illegible]	[illegible]	[illegible]	217	212
Jan.	[illegible]	207	[illegible]	170	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	203
Feb.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	197
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	217	201
April	[illegible]	211	217	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	216	203
May	240	[illegible]	[illegible]	[illegible]	172	[illegible]	[illegible]	217	[illegible]	207
June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	212	207
July	246	[illegible]	[illegible]	171	[illegible]	[illegible]	[illegible]	245	221	218
Aug.	[illegible]	[illegible]	[illegible]	175	[illegible]	[illegible]	[illegible]	[illegible]	225	226
Sept.	[illegible]	[illegible]	[illegible]	181	[illegible]	[illegible]	[illegible]	[illegible]	217	220
Oct.	[illegible]	211	[illegible]	181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	223
Nov.	[illegible]	219	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	230
Dec.	[illegible]	[illegible]	[illegible]	181	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1920	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	243
Jan.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	248
Feb.	[illegible]	[illegible]	[illegible]	187	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	249
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	265
May	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	272
June	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	269
July	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Aug.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sept.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Oct.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nov.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Dec.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1921										
Jan.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Feb.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
March	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
April	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Fabricating Shop Contracts in April. The records of the Bridge Builders & Structural Society, from reports collected by its secretary, show that during the month of April, 1921, 55,800 tons of fabricated structural steel were contracted for throughout the United States, equivalent to 31 per cent of the entire capacity of the bridge and structural shops of the [illegible].

Instructions to Foremen for Prevention of Accidents in Steel Erection

The erection department of the McClintic-Marshall Co., Pittsburgh, Pa., has issued recently a revised copy of its instructions for the foremen engaged in erection of structural steel. The suggestions in the booklet are of such general interest that we are reprinting them below.

Equipment and Tools. It is your duty to see that the equipment and tools you use for each part of the work are sufficiently strong to handle the work safely, are in good order and are properly used.

Derricks: You should see that the derricks you use are amply strong for the loads to be lifted. The goose neck and gudgeon pin are the critical points of a derrick. If you have any doubt about the strength of the goose neck, provide heavy wire guys from the gudgeon pin to the sill at the base of the stiff legs. Don't overload your equipment and don't run any chances where life is endangered. Don't lift a 10-ton load on a 5-ton derrick. Be careful not to lift any but a light load on a derrick if the length of the boom exceeds 70 times its least width or thickness; that is, if your boom is 12 in. x 14 in., the least width is 12 in. and you should not lift a heavy load on this boom if it is more than 70 ft. in length. Table I shows the maximum loads which may be safely lifted with timber booms.

In setting up your derricks see that they are plumb, properly guyed and bolted with tight-fitting bolts. See that the goose necks fit gudgeon pin closely and that they are not cracked or bent, and that the top of the stiff leg is tied down from the goose neck to the sill to prevent lifting tendency. In the case of a wooden derrick, if the timber in

TABLE I—SAFE LOADS IN TONS ON YELLOW PINE TIMBER USED AS BOOM.

Size in inches	Radius in feet 10	[illegible]	[illegible]	25	30	35	40	45	50
a. [illegible] 17-ft. Mast									
6x6x20	[illegible]		[illegible]						
6x6x30	[illegible]		[illegible]	1	1				
8x8x20	[illegible]	[illegible]	1						
8x8x30	6	[illegible]	[illegible]	6	5				
8x8x40		[illegible]	[illegible]	2	1				
b. [illegible]-ft. Mast.									
8x8x30	11	11	[illegible]	11	10				
8x8x40	7	[illegible]	[illegible]	4	2	1			
10x10x30	21	21	[illegible]	21	21				
10x10x40	14	14	[illegible]	13	11	9	8		
10x10x50	[illegible]	[illegible]	[illegible]	5	3	1			
c. [illegible]-ft. Mast.									
10x10x40	17	17	[illegible]	16	14	12	10		
10x10x50	11	[illegible]	[illegible]	6	4	2			
12x12x40	[illegible]	[illegible]	[illegible]	28	28	26	24		
12x12x50	[illegible]	[illegible]	[illegible]	17	15	12	10	7	5
12x12x60	14	13	[illegible]	7	5	2			
14x14x40	42	[illegible]	[illegible]	42	42	42	41		
14x14x50	[illegible]	[illegible]	[illegible]	31	29	26	23	20	17
14x14x60	[illegible]	[illegible]	[illegible]	19	16	13	10	7	[illegible]

Note.—The above table is based on a unit stress of $1000 - 10\frac{L}{D}$ for compression, and $1500 - 15\frac{L}{D}$ for combined stress compression and bending, where L = length in inches and D = width in inches. Table is figured on the use of a single lead line, and the load on a [illegible] part lead line, although the number of parts would depend on the load, and on the strength of the line used.

With a mast shorter than [illegible] the stresses in boom will be increased.

TABLE II—SAFE LOADS IN TONS ON YELLOW PINE TIMBER USED AS GIN POLE

Size in inches.	Length in feet	Maximum stress in guy [illegible]	Radius distance measured on ground between foot and top of pole. 5	10	15	20	25	30
6x6	20	[illegible] tons	4	4				
8x8	20	8 tons	10	8				
	30	8 tons	8	7	[illegible]			
10x10	20	14 tons	[illegible]	14				
	30	12 tons	14	13	11			
	40	10 tons	12	11	10	9		
12x12	30	[illegible] tons	23	20	18			
	40	16 tons	20	18	17	15		
	50	12 tons	17	16	15	14	11	
14x14	[illegible]	[illegible] tons	33	30	26			
	40	[illegible] tons	30	28	25	23		
	50	[illegible] tons	26	25	23	21	20	
	60	[illegible] tons	22	21	20	18	15	12

Notes: The above table is based on a unit stress of $1000 - 10\frac{L}{D}$ for compression, and $1500 - 15\frac{L}{D}$ for combined stress (compression and bending), where L = length in inches and D = width in inches. It is figured on the use of a single line, although the number of parts would depend on the load and on the strength of the line used.

It is assumed that the guys are fastened at a distance from the foot of the pole not less than the length of the pole itself. If this distance is decreased, the stress in the pole increases.

The stress in the guy line decreases in about the same proportion as the radius.

the mast, boom, stiff legs or sills are rotten, knotty or wind shaken, do not use them. See that your gudgeon pin and pintle casting are well fastened to the mast, and if the mast is of wood, see that the wood is not rotten or worn at these points.

When you use a derrick keep the boom elevated above a horizontal line as far as possible, as generally the greatest stress comes upon the boom and mast, as well as stiff legs or guy lines, when boom is in a horizontal position. A maximum load for the derrick should never be lifted with the boom in a horizontal position.

In using a guy derrick you must be sure that the foot block of the derrick is braced solidly in all directions, and that the tensions on the cable guys are so adjusted by the turn buckles that there will be more than one guy to take the stress in any position of the boom. Do not use chains for connecting guys to columns, but use cable in all cases. The lead blocks must be inspected daily, as the sheaves are very apt to wear. See that the floor beams are bolted up solid, and that the beams directly under the derrick are shored if necessary. Shoring is necessary if the beams are not twice as strong as required to carry the maximum load of the derrick, with the boom in the position which brings the greatest load upon the foot block. This extra factor of safety is required in order to be absolutely certain that the derrick is safe should anything unforeseen happen.

Nearly all the accidents which occur in connection with guy derricks are due to either the foot of the derrick kicking out, or the anchors for the cable guys breaking at the point where they are attached to the column, or pulling out of the foundations when the derrick is set up in the basement of a building.

In case of both gin poles and derricks, it must be remembered that the use of several parts in the load line, by reducing the pull in the lead line, reduces the stress in the pole or boom considerably; in other words, the capacity is increased by increasing the number of parts of the load line.

Gin Poles: Do not use an iron gin pole if the sections are bent or dented seriously, nor if the splices do not clamp the pole tightly and securely. Do not use a wooden gin pole unless the timber is in good condition, well spliced, with good, long splices securely bolted. Don't lift a heavy load on a light pole. Table II shows the maximum loads which may be safely lifted with timber gin poles.

When you use a gin pole see that it is properly guyed with the guys as near to right angles to each other as possible. Avoid the attachment of guy lines to railroad tracks, as numerous accidents have occurred by car running into guys. Do not lean the pole too much when lifting a load or moving the pole and see that the foot of the pole can not move or slip except when you desire to move it.

Travelers: When you use a wooden traveler see that the timbers are all in good condition, that it is carefully framed, well braced and erected plumb and square, with all joints properly and securely bolted; capable of withsttanding the greatest wind, and shocks from the heaviest loads that are to be lifted. More accidents occur from the use of wooden derricks and wooden travelers than from any other cause, and for this reason extreme care should be exercised before using them. When a steel traveler is used, see that it is properly erected and thoroughly bolted and all sway and bracing rods tightened.

Manila Line and Cables: Do not use old or worn line when there is any danger to men or material by so doing. Avoid the use of manila line, and when you are obliged to use it be sure that it is amply strong. Use steel cable whenever possible, as it is safer, will last longer and is cheaper in the long run. Be sure that the guy cables for the gin pole, derricks, etc., are of sufficient size to withsttand the tension to come upon them, that the cables are securely fastened by means of a sufficient number of good, strong clamps and that dead men or other anchorages are ample; and watch them, when lifting heavy loads to see that guys do not cut dead men in two. Keep gin pole guys as near at right angles to each other as possible, when only four are used.

All cables should be in good condition and kept well oiled or greased so that they will not rust; if they are not in good condition, do not use them. All guy cables should be securely fastened by a sufficient number of clamps, the nuts on the clamps being placed over the short end of the cable.

Avoid the attachment of guy line to railroad tracks, as numerous accidents have occurred by a car running into the guys. In guying trusses or other parts of a building you must use cable guys with a short length of manila line reeved up at the foot, to enable cable to be securely tightened. Lines should be run around two winch heads when making a heavy lift.

You should see that all leads are as straight and direct as possible, as failure to provide good leads reduces the efficiency of your power and equipment, as well as producing heavy wear on the lines, and is a frequent cause of accidents. Particular care should be exercised in securing good leads for wire cable on account of liability of breaking the individual wire strands by sharp bends or indirect leads. A broken individual wire is liable to lie across and cut the other wires of the cable.

Blocks: See that your blocks are in good order, that faces of blocks are in good condition and that the sheaves are not cracked or the flanges broken. Do not allow a gate block to be used without being closed, hooked and securely fastened. Do not use a light gate block when lifting a heavy load. See that the beckets, shackles and hooks are amply strong, and that they are not bent, cracked or out of shape.

Chains: See that your cables and chains, as well as the rings and hooks in the same, are amply strong for the loads to be lifted; that they are not worn, cracked or bent out of shape and that the chains are annealed at least once every three months in an annealing furnace, if you are near one. Otherwise anneal them yourself, by laying them down in a straight line and building a good size wood fire over them, heating slowly to a cherry red, then covering over thoroughly with ashes and heated dry earth, leaving them to cool slowly in the ashes and earth. In laying the chains down, in a straight line, do not lay one chain on the top of another. Be particular to see that the covering is ample so that the air or moisture cannot cool the chains quickly or partially. This annealing should be done on Saturday and the chains not disturbed until Monday. Chains used frequently every day should be annealed once a month.

Scaffolds: You should be careful to see that the gas pipe or wooden scaffold you use is of proper size and strength for the span and loads. See that gas pipe scaffolding is not rusted on the inside and that it is fastened so it cannot roll or turn. Do not splice gas pipe for scaffolding. See that plank you use for scaffolding, etc., is the right kind of wood, preferably white pine or spruce, free from knots and shakes, and amply strong and see that it is thick enough for the span on which it is used. Do not use any plank or timber that is knotty, rotten, or weather cracked. Do not allow men to work on scaffold plank laid loose on the supports; the plank should be fixed so it will not slide endwise, by using drop bolts. These drop bolts must have a nut on the other end in order that there may be no possibility of the bolts falling out should the plank be turned over. If there is any question about the strength of scaffolding, test the same by applying several times the load that will come upon it.

In suspending scaffolds by means of eye-bolts, you must always use two nuts on the bolt, and drill a hole through the bolt for a cotter pin. Fatal accidents have occurred as the result of a single nut on an eye-bolt working loose.

In certain states the law requires a railing to be placed around scaffolding. It is not always possible to comply with this, but you must remember that in case an accident occurs on account of no railing having been used, the burden of proof that it was impossible to use one will be upon us. You must, therefore, take particular care in the case of men working on scaffolds not protected by a railing.

Push Cars: A number of accidents have occurred through the improper loading of push cars. See that the load is properly placed so that it cannot roll or tumble over, especially in going around a curve. Do not put heavy loads on light push cars. The frame is not only liable to crush but the shafts, boxes or wheels may bend or break, upsetting the load and injuring the men. Do not allow men to push on the side of a car with a top heavy load. They should push or pull from the ends of the piece.

Hoisting Engines: See that your hoisting engine is in good order; that the shafts are not bent, and that the dogs, clutches and brakes, including the friction, are in good condition and working order. The lever controlling winch heads should be straight and when thrown in should engage and ratchet fully. See that winch head cannot slip off shaft. See that the boiler is cleaned once a week if it is being used continuously, or if the quality of the water is poor, and at least once every two weeks under ordinary conditions.

Locomotive Cranes and Derrick Cars: If using a locomotive crane be sure that your track is properly ballasted and level and the rails well spiked down. Do not lift a load sideways when the locomotive crane is standing on a curve, without using outriggers and rail clamps. If the load is heavy, outriggers and rail clamps must be used even when track is level and the load directly in front of crane.

The loads that a locomotive crane is capable of handling safely for each radius are plainly marked on the crane; don't attempt to lift heavier loads with the crane.

See that the booms of locomotive cranes, derrick cars or derricks, are in first class condition. If the boom (or flanges of the boom) has been injured or bent, don't use it, but replace the broken or bent part with new material. Don't attempt to straighten it, as the material in all probability has been injured, and will break or collapse sooner or later.

A locomotive crane is a useful, but dangerous, piece of equipment; for this reason the greatest possible care should be exercised in handling the same. Don't allow any man on the car or crane cab, except the cranemen, and keep workmen from under the boom. Don't attempt to shift track upon which crane is standing, unless track is cut. Don't attempt to lift a maximum load with the boom horizontal.

You must be especially careful in swinging boom sideways or lifting loads sideways with a derrick car, as your car will upset unless you use outriggers or guys. Don't run chances, but lift the load straight ahead wherever possible. See that the boom on the derrick car is tightly guyed at all times with wire rope running from end of boom to sides of car. Never use manila line for this purpose, as it will stretch, and the boom will get away, upsetting the car. Use additional guys to end of boom when setting heavy loads.

In carrying loads with a locomotive crane or derrick car on a curve, be sure that the track is level and the outer rail not elevated, as is customary with railroad track.

Be very careful, in using a wooden boom extension or outriggers, that you do not lift too heavy loads. The increased length of the boom, and the weight of the extension, reduce the lifting capacity considerably.

General: See that all button sets are fastened to the air hammers. Hook on to sheets or bundles of small material, so that they cannot slip out.

Do not allow men to carry glazed window sash on their shoulders when wind is blowing.

See that men do not stand in the "bite" of a line.

Do not allow men to do work which may endanger the eyes, as chipping, cutting, etc., unless their eyes are protected by goggles.

In setting steel, see that each piece is securely bolted before the line is thrown off.

When you lift a beam or girder use scissor dogs or cast steel girder hooks wherever possible, and if you are obliged to use either ordinary dogs or chains see that wooden blocks are used between the chain or dog and the flange to prevent the girder from slipping. Never lift two or more beams at once without using a twin chain or sling.

Avoid the use of chains except for lifting light loads. Where you have heavy loads to lift use cable slings, being careful to avoid sharp bends by using rounded wooden blocks between cable and load.

Remember that the capacity of a twin chain or twin sling diminishes the further it is spread. If spread to 90° its capacity is only 70 per cent. and if to 120°, only 50 per cent. It should never be spread more than 90° except for very light loads.

Don't put too many parts of lashing into a hook, as by doing so you are liable to open up the hook.

See that exposed parts of dangerous machinery are properly covered.

Be Orderly and Careful: See that your work is carried on in an orderly, careful manner.

See that material is unloaded and piled in an orderly, careful way so that it cannot fall, turn or be blown over.

Unless necessary, do not hoist any material to a structure until you are ready to put it into position and properly fasten it. In cases where you do hoist material to the structure before putting it in its final position, see that it is piled in an orderly way so that it can not turn or roll over if a man steps on it.

Don't let tools or equipment such as bolts, nuts, drift pins, blocks, dolly bars, etc., lie around so that they can be knocked off the work or so that any one can fall over them.

Keep everything orderly and ship-shape and allow nothing to lie around.

Be Vigilant.—You must use vigilance and be on the job practically all the time to see that your men are carrying out your instructions; that they are in fit condition for the work and that they are handling the work carefully and intelligently.

Be careful, and insist on the men under you being careful, and do not allow any one who is reckless or careless to work for you.

Whenever any question as to the safety of equipment or tools, or the work which you are erecting is brought to your attention by any of the men under you or others, investigate the matter and satisfy yourself of its safety before proceeding further. If you are satisfied the work, equipment or tools are not safe, put them in a safe condition immediately.

See That Proper Instruction Is Given Employes.—Call attention of men to any dangerous conditions on the job so that they can be on the lookout.

Your faithful attention to this matter is to the interest of employe and employer alike.

Unfit Condition.—You must see that every employe under you is in proper physical condition. They should be strong, temperate, clear-headed, with good eyesight, good hearing, and not lame or crippled. Do not allow any man to go to work who has been drinking or who drinks during working hours, or who is sick or in unfit condition. A man's mind is not clear who is at all under the influence of liquor and thus endangers his own and fellow workmen's lives.

Don't employ ignorant persons.

Don't employ any one under 18 years of age and preferably no one under 21. Those employed between the ages of 18 and 21 should be strong, sober, healthy boys who desire to learn the business. You must secure a written permit from the parents of all boys under 21 years of age, authorizing you to employ them. Forms for this purpose will be sent you.

The character of this business is such that a workman must be strong and sound in body, temperate in habits, and clear and alert in mind, to avoid accidents.

Use Judgment.—You must use judgment in assigning men to do certain work and see that they are capable and experienced in the work to be done.

Signal men should be capable, experienced bridgemen, and should stand in a position where they can be seen by the men at the hoisting engine and those handling the work. Signals should be clearly understood. Use none but good, careful, experienced locomotive cranemen, derrick car men, and men on winch heads.

Don't resort to expediency by allowing an inexperienced man to do the work where experience counts. Educate the men up to their work. Don't throw too much on inexperienced men all at once.

You should see that the pusher and men use proper tools to do the work and handle same properly.

Where there are heavy pieces to be lifted see if the weight is marked on the piece; if not, get the weight from the invoice and mark it on, calling pusher's attention to it.

Do Not Allow Men to Work in Perilous Places.—You must see that your men are not exposed to extremely hazardous conditions and that they are not allowed to work in extremely dangerous places.

Don't allow men to work on crane runway when cranes are in motion.

Don't allow men to work on scaffold that you would not work on yourself.

Don't allow men to work under loads and in places where there is imminent danger.

Don't allow men to work on the roofs of buildings where there is frost, ice or snow, without taking extra precautions. This also applies to other steel structures.

See That Workmen Obey the Following Rules.—More accidents occur through recklessness than any other cause. Don't walk on rods. Don't ride a load. Don't ride on a locomotive crane.

Don't Be Careless: Look where you step and be sure that on what you step is safe and secure. Don't step on ends of loose plank. Don't start to slide down a line unless you are sure the ends are fastened.

Be Orderly: Do whatever you do in an orderly, careful manner. Pile material so that it cannot roll, fall, tumble, or be blown over. Don't let tools or equipment such as bolts, nuts, drift pins, blocks, dolly bars, etc., lie around so that they can be knocked off the work or so that any one can fall over them.

Unfit Condition: Don't go to work if you have been drinking or do not feel well. If you are lame or have any defect in hearing or eyesight you should not work at this business as by so doing you endanger your own and fellow workmen's lives. If you are inexperienced in or unsuited for the work to be done, don't undertake it.

Be Vigilant: Watch what you are doing. Don't stand or work under a load. Don't go in the "bite" of a line nor stand in front of a snatch block. Don't work on or about a crane runway when the crane is in use unless there is a stop between you and the crane.

Don't Use Unfit Tools: Be sure the tools and equipment you use are in good working order. If they are not, don't use them.

Don't work with men who don't observe these rules

Engineers to Aid in Solving National Housing Problem.—Seven engineers have been designated by Secretary Hoover to aid the Department of Commerce in solving the National Housing problem. The seven who will act as an advisory committee to Secretary Hoover are: Ira Woolsor, consulting engineer of the National Board of Fire Underwriters; Rudolph P. Miller, engineer in charge of building ordinances of New York; J. A. Newlin of the University of Wisconsin; J. R. Worcester, consulting engineer of Boston; William K. Hatt of Purdue University, Ernest J. Russell of St. Louis and Edwin H. Brown of the American Institute of Architects.

Rigid Frame Construction for a Factory

A rigid frame reinforced concrete construction for a factory is described in the April 21, 1921, issue of the Canadian Engineer. The factory was constructed for Machinery and Foundries, Ltd., of Brockville, Ont., and consisted of a 1-story foundry building, 62 by 148 ft., connected in the form of an L with a 1-story machine shop, 57x277 ft.

An interesting feature was the use of rigid frames as bents the desirability of reducing to the minimum the number of members or parts so that the form work and the placing of reinforcement might be simplified as much as possible. A circumstance greatly affecting the design, not only of these frames but also of the bents for the machine shop, was the fact that the rock at the side of the buildings was practically at the surface, thus obviating the necessity for footings. Without footings thoroughly anchored to the rock, however, it became necessary to consider the bases of the columns for the frames, as well as for those elsewhere, as free to turn. Under transverse wind force, therefore, large bending moments would naturally be developed at the under side of the roof girders, and special provision had to be made for these.

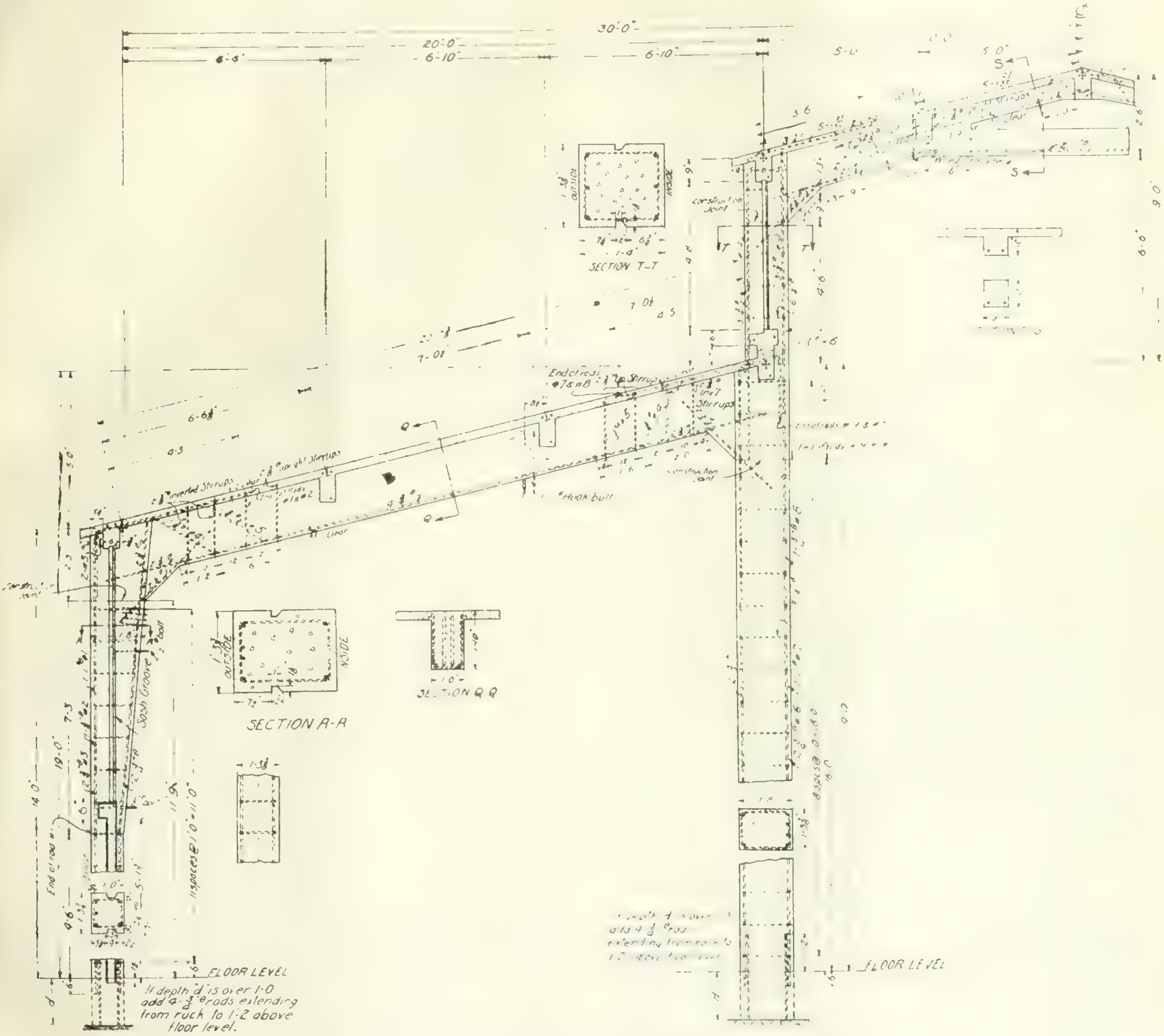


Fig. 1—Typical Rigid Frame for 14 Ft. 2½ In. Foundry Bags.

An interesting incidental problem involved in the design of these frames was the determination of the horizontal component of the reaction at each column base. As a first approximation it was assumed that the moments of inertia of [illegible] the foundry building. The width [illegible] was divided into three equal bays, the [illegible] consisting of four columns, with two inclined side rafters and a monitor carried by the two interior columns.

The whole frame was built up as a monolithic structure, and thoroughly reinforced at joints to take the bending stresses developed by the various combinations of loading. In arriving at the form of the frames, regard was had to all four columns were equal, and the following formula from Hool & Johnson's "Handbook of Reinforced Concrete Construction," page 429, was employed

$$H_A = \tfrac{1}{2}Pk[\,2kS + R(1 \ldots k \ldots S \ldots k \ldots + R(1 + k + k \ldots)]$$

where H_A = horizontal component of reaction at base of outside column; P = horizontal load transferred through monitor to leeward side shed; k = ratio of height of interior and wall columns from ground to rafter; S = ratio of moment of inertia of rafter and columns, the columns being assumed as having equal moments of inertia; and R = ratio of length of rafter to height of wall column.

Application of this formula showed that of the horizontal load carried by half of the bent, the short column takes 65 per cent and the long column 35 per cent.

The maximum moment in the wall column occurs at the haunch and equals horizontal reaction at the foot of the column multiplied by its arm about the haunch.

To provide for this moment, the columns were battered on the inside above a point 4 ft. 6 in. above floor level, where they were 12 in. wide, to the under side of the roof slab, attaining a width of 20 in. at the bottom of the girder haunch. The heaviest tensile stresses are, therefore, on the outside of the leeward column near the top, and to withstand these, three ¾-in. diameter rods and one 1-in. diameter rod were utilized, in the case of the typical column, Fig. 1, from the beginning of the batter up to the under side of the roof slab. The high combined bending stresses across the roof girders at the end made haunching necessary. The tension at the top of the girder is taken up by the two ¾-in. diameter rods bent up from the girder, plus two rods carried up from the column and over into the girder to about the quarter point.

The buildings were designed for a snow load of 30 lb. per square foot, and a wind load of 20 lb. per square foot of vertical surface. The working stresses on the concrete were assumed as follows: 700 lb. in compression due to flexure, 500 lb. in compression on columns longitudinally reinforced, 50 lb. in diagonal tension. The working stress in the steel in tension were 18,000 lb. per square inch.

Concrete was generally of 1 part Portland cement, 4 parts crushed stone with a maximum diameter of ¾ in., and sufficient sand to fill the voids and 10 per cent excess. Reinforcing steel was of a medium structural grade; plain, round sections were used.

Some Steel Price Comparisons

Substantially identical prices, as between the United States Steel Corporation and the independent steel producers, have developed again, and comparison of prices at various times is befitting. The course of steel prices may be reviewed briefly. The general substitution of mild or soft steel for wrought iron was completed before the end of the industrial depression of 1893-98, and by a combination of rich Mesabi ores, low wages and economies generally very low prices ruled in 1897 and 1898. Afterward there were various ups and downs and at the end of 1914 the lowest prices since 1898 were reached. Leaner ores were then used than in 1898 and wages were about 50 per cent higher, but manufacturing processes were much better.

During the war steel prices advanced and after the entrance of the United States the advances were spectacular. Then came Government price control. Dec. 13, 1918, slight reductions were made by the mills, as a step in deflation, and through the instrumentality of Secretary Redfield's Industrial Board further reductions became effective March 21, 1919. From then until last week the United States Steel Corporation adhered to the Industrial Board prices. The independents at first cut those prices, until some time in June, 1919, and late in the year they advanced over those prices, while in 1920 there was a wildly advancing market on the part of the independents, with continued expectation on their part that the Steel Corporation would advance its prices. Such expectations were disappointed, and by the end of 1920 the independents were back to the Industrial Board or Steel Corporation prices. During January of this year there was a uniform market, while in February the independents began cutting. Early in April the independent market firmed up somewhat and then, effective April 13, the Steel Corporation made certain reductions in its prices, whereby the independents and the Steel Corporation are again at the same level.

Using a weighted average of the important steel products according to their tonnage importance, including bars, shapes, plates, pipe, wire, sheets and tin plate, a fairly complete summary of steel price movements can be made in small compass, as given below:

Ten-year average, 1904-1913	$36.00
Five-year average, 1909-1913	34.00
Year 1913	34.50
Dec. 31, 1914	28.50
High, July 1, 1917	114.00
Government control	76.00
Dec. 13, 1918	72.00
March 21, 1919	65.00
Independent high, 1920	93.00
Dec. 31, 1920	65.00
Independent low, March 1, 1921	57.50
Present general market	60.00

In price comparisons in general of late, various bases for a pre-war level have been taken, and in the foregoing presentation several are therefore given for steel. The figures represent prices in dollars per net ton as a weighted average of the finished products just mentioned.

Pre-war averages are much the same, whatever period of years be taken as a basis, but pre-war high and low points are a different thing. We are not looking now for pre-war prices, for neither wages nor freight rates will get back to pre-war levels, but there is room for argument as to whether we should look for prices in relation to pre-war averages or prices in relation to pre-war low points.

Taking $35 as a mean of pre-war averages, the present finished steel market is 71 per cent above that basis. On the other hand, it is 35 per cent below the high prices of independents in 1920, not the highest prices charged on small lots for prompt shipment, but the prices obtained on moderate sized lots for ordinary deliveries. It is 21 per cent below "Government prices" and 47 per cent under the very fancy prices ruling just before the Government undertook to take control as a necessary war measure.

Can we compare the 71 per cent excess in steel prices over the pre-war average with the relations that other commodities show to their pre-war averages? Some undertake to do so, but the showing depends simply upon what commodities are taken. Tin, copper, antimony, aluminum, lead and zinc are all below their pre-war averages. According to a statement prepared by the Bankers' Economic Service, rubber, compared with its average Feb. 1 in each of the five pre-war years, is at 18 per cent, or less than one-fifth price, hides are at 62 per cent and coffee (wholesale) is at 63 per cent. Brick and lumber, on the other hand, are at more than double prices, 264 per cent and 222 per cent, respectively, while cement is set at 317 per cent.

Steel, apparently, would search in vain outside the industry for a standard. The industry will have to develop its price level from within.—Editorial in April 20 issue of Chemical and Metallurgical Engineering.

Discoloration of Indiana Limestone.—In order to eliminate the brown stains which frequently appear on new limestone masonry and which are thought to be due to the mortar, tests have been started by the U. S. Bureau of Standards to determine the effect of using colorless waterproofing materials on the limestone at points where it comes in contact with the mortar. The indications are that if water can be prevented from leeching through the mortar and entering the limestone that stains will not occur. The tests indicate that the greater part of the stain can be prevented by this means. Another method of eliminating the stains, which is being tried, consists of coating the exposed face of the limestone walls as they are built with a porous coat that can be readily removed. The stains come through the coat and form on the outer surface and by removing the coat the stain is removed also. The insoluble nature of the material which forms the stain makes it very difficult to remove from the limestone, but by allowing it to form on the coating, as mentioned above, it can be readily removed. Since most of these stains form during the erection of the masonry, the method may prove of some value.

Design and Construction of Foundations for Highway Bridges

Speaking generally, a bridge structure consists of three portions or parts, viz.: (1) The superstructure or spanning portion supporting, in addition to its own weight, pedestrian, vehicular, and other so-called "live" loads; (2) The substructure supporting the superstructure with its loads; and (3) The foundation which supports the substructure with its superimposed loads.

Obviously the stability of the entire structure depends primarily upon the efficiency of its foundation. While science, skill, and experience combined with the progress of the time have achieved marked success in evolving the rationale of bridge design and in producing and developing new types of superstructures and substructures, a far less degree of attention has been bestowed upon the development of fundamental principles and reliable information and data relating to the bearing power of soils, and to methods and operations involved in the design and construction of foundations. An interesting discussion of this last mentioned feature was given by Mr. L. N. Edwards, Senior Bridge Engineer, U. S. Bureau of Public Roads in Public Roads, a publication of the Bureau, from which the matter is this article is taken

Conditions Affecting Stream Scour.—With an occasional exception, the construction of bridges over streams has the effect of obstructing free stream flow by contracting the channels and by producing eddies, cross currents, whirlpools, etc., resulting in accentuating any tendency that may exist to erode or scour the beds during periods of high water. The location and extent of scour is mainly dependent upon the courses of the streams, the rate of their currents, and the character of the soils forming their beds. The greatest scour will generally take place in the vicinity of the portions of the structure furnishing greatest resistance to the free flow of the water. In general, piers and abutments should have their foundations located well below the range of possible scour. However, to render them secure against unforeseen eventualities they are often protected by the installation of riprap, stone filled cribs, brush mattresses weighted down with large stones, concrete aprons, etc.

Importance of Adequate Foundation Surveys.—In general, the loads considered by the designer, in proportioning bridge pier and abutment footings are: (1) the total dead load of the superstructure and substructure, (2) the live load including under certain conditions an allowance for impact, and (3) earth pressures in the case of abutments acting as retaining walls. To the foregoing may be added (4) forces induced by temperature in the case of piers and abutments for arch spans, and (5) wind, ice, or other external pressures in exceptional cases. In the absence of definite data as to the bearing value of the foundation this definement of load calculation would be of no advantage. It is therefore of basic importance that the designer be in possession of all available information relating to foundation conditions. The securing of this information necessarily involves a survey of soil conditions by making borings, sinking test pits, driving test piles, etc., to discover sub-surface conditions. It also involves a general survey to obtain data relating to the size of the drainage area, rate of stream flow, direction of stream currents, high and low water elevations, possibility of accumulations of drift, etc., likely to affect stream scour, together with a contour survey of the bridge site.

The general formation, density, and thickness of strata of soil vary so much that the testing of the foundation soil and the depth of underlying strata is absolutely necessary for the determination of the allowable pressures that may be placed upon the foundation material. The course, depth, and velocity of the stream in the vicinty of the bridge site, together with natural conditions influencing the future development of surrounding property, should receive full consideration in their relation to stream currents and scour of the stream bed.

Too frequently survey plans provide insufficient information for the preparation of the design and the working drawings of bridge structures. The character of the foundation materials is too often assumed to be the same as that showing upon the surface at the bridge sites. Occasionally the superficial examination of the soil is primarily due to the fact that the equipment of the survey party does not even include a mud auger with which to make the simplest kind of a sub-surface examination. However, there are other factors which sometimes enter into the field survey work. The observer, not realizing the importance of accurately describing the character of the foundation soil, fails to incorporate a proper description in his field notes; or, what is even worse, the draftsman preparing the survey plan, believing that "brevity, brevity always" is a mark of efficiency, will eliminate all tendencies to verbosity and will concentrate paragraphs into single words such as "clay," "gravel," "bowlders," etc.

Effect of Inadequate Foundation Survey on Design.—To emphasize the importance of the foregoing it may be of value to cite an actual case of construction work. The bridge referred to was located at the outlet of a comparatively large lake. The survey party, although equipped with a mud auger outfit, made only a surface examination of the soil and the survey plan prepared from its field notes showed "bowlders with clay" as foundation material. "Bowlders with clay" constitute under certain conditions excellent foundation material. However, in this particular case the "bowlders" were merely "one man" stones which had been deposited along the river banks by ice floes. Knowing nothing of the field conditions other than was shown upon the survey plan the designer assumed a foundation pressure which seemed justified by the description and designed the substructure accordingly, placing the foundation elevation at a depth below possible frost action. When the foundation pits had been excavated to a depth of 2 to 3 ft. all of the "one man" stones had been removed and the underlying blue clay was soft and altogether unreliable as a foundation material. Soundings were made with a steel bar by one of the workmen which indicated the existence of firm material at a depth of approximately 3 ft. below the foundation elevation shown on the substructure plan. When the overlying clay had been removed a hard, durable limestone foundation was secured. This material was capable of safely sustaining a much greater load per unit area than had been assumed in the original design and, had conditions permitted, a considerable economy could doubtless have been affected by redesigning the entire substructure.

Pressure Distribution Not Always Uniform.—Having discovered the character of the foundation material by a careful survey, it is important to remember that foundation pressures are not always uniform. Other conditions being equal, a pier symmetrically loaded and symmetrically shaped will produce a uniformly distributed pressure upon its foundation, but irregularities in the lengths of superstructure spans, cut water construction on the upstream end, subjection to heavy ice floes, etc., tend to produce variable foundation pressures. Abutments are commonly so located as to perform the double function of supporting the superstructure and resisting the pressure of the earth fills forming the bridge approaches. The pressure exerted upon an abutment foundation is, therefore, rarely a uniform one and in consequence, the so-called "toe-pressure" is greater per square foot of foundation area than is the "heel pressure."

The pressure per square foot used for designing purposes should be well within the safe bearing power of the soil; that is, a pressure which will not produce appreciable settlement. If, perchance, an undue settlement takes place, the abutment will tilt forward and may ultimately result in a total failure of the structure.

Structural Weaknesses Due to Substructure and Foundation Movements.—One of the distinctive advantages resulting from the common practice of building piers with battered sides and ends and abutments with battered face surfaces on the body and wings is that a slight tilting may take place without giving to the substructure an overhanging and unstable appearance. It is important in this connection to call attention to certain structural weaknesses resulting from substructure and foundation movements. Almost without exception such movements subject the superstructure to stresses for which no provision was made in its design, though the actual condition existing may not become fully apparent even by the most careful and critical examination. A pin-connected truss span gives greater evidence of the conditions mentioned than does a riveted span. By reason of a slight derangement of the correct alignment of the bottom chord pins, a portion of the eye bars become loosened, thereby rendering them partially or entirely inactive with the natural result that the stresses these bars were designed to carry are actually carried by the other bars. Structures composed of mass and reinforced concrete frequently give evidence of [illegible] and foundation movements [illegible] structures the induced stresses appear [illegible] the weakest portion and in consequence, the [illegible] may take most unfortunate courses and by progressive action may result in the development of very dangerous structures or possibly in failures.

Speaking generally, foundations are either natural soils, including rock formations, or artificial foundations consisting of compacted soils, soils reinforced with piles, grillages, etc.

Natural Soil Foundations.—Natural soils are an ever varying quality, heterogeneous in their composition and stability. Their bearing power depends mainly upon the general formation, texture, density, uniformity, and thickness of the strata. A stratum composed of a soil having, under ordinary conditions, a comparatively low bearing power may be so confined by a thick, strong overlying stratum that it will sustain with ample safety a greatly increased load. A similarly placed stratum located with an outcropping in the hillsides of a deep ravine or river valley may be subject to a very slow oozing flow under the pressure of a superimposed abutment or pier, which will ultimately result in a sufficient settlement of the foundation area to produce appreciable superstructure deformations. Usually under these conditions the vertical movement is combined with a lesser movement of the overlying material, producing a horizontal displacement of the bridge structure. Such movements may involve a period of months or even of years to become fully developed. They may continue at a practically uniform rate or may become accelerated by reason of a weakening of the overlying strata resulting from fissures, fault lines, etc., existing within them.

Natural soil foundation materials are divided into five general classes, viz: (1) Bedrock, (2) gravel, (3) sands, (4) clays, and (5) ordinary soft soils and earths.

Bedrock and "Near Rock" Foundations.—Bedrock is, as a general rule, practically secure against stream scour and under ordinary working pressures is incompressible. However, its surface may be irregular, presenting shelly areas and numerous cracks and fissures, through which water frequently flows very freely, rendering the work of preparing foundation areas costly and difficult. On the contrary, it may present a surface worn smooth by glacial or water action and rounded or tilted at such an angle with the horizontal that it becomes necessary to level it horizontally as a whole or in steps in order to render the substructure, piers, or abutments placed upon it secure against scour, sliding, etc.

The influence of the elements upon bedrock must be taken into consideration, especially when outcroppings are contemplated for use as foundations, as certain rock formations are subject to disintegration when so exposed.

The brief discussion of bedrock materials here given would be incomplete without a reference to that grade of soils, which, for want of a better nomenclature, will here be referred to as "near rock." It is especially important to exercise caution whenever these materials are being considered for foundation purposes. The most common of these are:

(a) Soft shale, sandstone, limestone, and other rock-like material generally known as "rotten rock."

(b) Very compact and shale-like beds of clay which are subject to rapid disintegration when subjected to scour.

(c) Beds of compact clay, similar to the above, which tend to slake when subjected to atmospheric conditions.

(d) Beds of cemented gravel or sand which disintegrate freely when subjected to scour.

As a general rule, "near rock" soils are appreciably compressible when submitted to fairly high unit pressures and, in addition, many of them disintegrate freely when subjected to the erosive action of swift currents.

Gravel as a Foundation.—Gravel varies widely in its granulometric composition and in the original rock material of which it is composed. Gravel is not readily defined since its many uses in bridge, road, and other construction work have established for it various limitations as to maximum and minimum sizes of particles. However, a somewhat commonly accepted definition is: "Small worn fragments of rock material which will pass through a screen having holes 2½ in. (2½-in. screen) in diameter and be retained upon a sieve having four meshes per linear inch (No. 4 sieve)." In so far as its use as a foundation material is concerned, the term "gravel" is very generally applied to material having approximately the above-described grading intermixed with sand.

A gravel having its particles well graded from coarse to fine and firmly cemented with a natural earthy cement containing iron, silica, lime, or other comparatively stable cementing material, if existing in a stratum 4 to 8 ft. or more in thickness, is practically incompressible under the pressure produced by ordinary bridge structures and provides an efficient foundation even when overlying a less reliable substratum. Well cemented gravel will withstand the disintegrating influence of a quite rapid current. Slow disintegration may sometimes result from dissolution of the cementing medium. The cemented gravels here referred to must not be construed to mean the hardest grades of conglomerates which quite properly may be considered as bed rock, but, instead, the softer conglomerates which can ordinarily be broken up in an excavation by the use of a pickax.

A confined gravel stratum made up of loose but well compacted material, free from the disintegrating action of water flowing through it is only slightly compressible under ordinary foundation pressures.

Foundations in Sand.—Sand, like gravel, varies widely in its granulometric composition, in its petrography, and in its other physical properties tending to render it satisfactory or unsatisfactory as a foundation material. It may exist as a firm, well cemented, granular material practically incompressible under favorable conditions or, on the contrary, it may, when fine grained and saturated with water, exist as a soft, yielding, semifluid material quite unreliable for foundation purposes. As in the case of cemented gravel, above described, the cementing medium is commonly a natural earthy cement containing iron, silica, lime, or other cementitious material. Special care must be exercised whenever the cementing material is readily soluble in water, since its subjection to the action flowing water would cause a disintegration of the foundation.

Compact sand, thoroughly confined against lateral movement by overlying strata or otherwise, and existing in beds 6 to 10 ft. in thickness, is considered an excellent foundation material, provided its stability is not endangered by a free flow of water through it. "Quicksand when properly drained makes a very stable earth, but when subjected to saturating water it becomes a hopeless mess."

Sand originally deposited by the action of water commonly exists in layers or strata varying widely in their granulometric composition. Quite frequently these strata have been deformed by subsequent movements so that they are tilted at an angle with the horizontal. A firm, well compacted stratum so tilted may be rendered useless for foundation purposes by an unreliable substratum containing an unstable loose sand, clay, or other unsatisfactory material which will fault when subjected to foundation pressures.

Clay an Uncertain Foundation Material.—Clay may exist as a firm, unyielding material resembling shale rock and having both cohesion and density, or on the contrary it may exist as a pasty, semifluid material having very little supporting power. This range of variation in its physical composition renders it one of the most uncertain and unreliable of foundation materials. Speaking generally, the best clay deposits of the former class are quite impervious to water and when protected from the disintegrating action of flowing water are quite reliable as foundation materials; however, it may here be remarked that some of the most dense clays are very readily scoured; also that clays giving fair evidence of stability will very frequently, through absorption of water, become less stable and compact, thus losing the important elements of a good foundation material. Not infrequently clays are encountered which, when subjected to foundation pressures, will squeeze and ooze like a firm India rubber.

"Clay even if found in hard condition is subject to slight compression, which, while uniform, may not be of much consequence." However, mention has been made above that the foundation pressures produced by abutments and retaining walls are very commonly variable from front to rear of wall, thereby tending to produce an uneven settlement. Drainage of clay foundation areas will increase their stability and bearing power.

Clay strata which have been deformed and are tilted at an angle with the horizontal are subject to possible slipping along natural cleavage planes rendering them to a greater or less degree unreliable as foundation materials. Their dependability in such cases is based mainly upon the strike angle of the formation and the physical character of the clay strata composing the general mass. In this connection, it is important to call attention to the fact that clay strata frequently contain fissures and fault lines running at random through them. An eroded hillside may expose these planes of natural weakness in such a manner as to render a hillside foundation of clay material rather uncertain as to its effectiveness.

Ordinary soft soils and earths, when considered as foundation materials, vary in relation to the proportions of sand, clay, or other firm materials they contain; however, in general these soils will support only very small foundation pressures. They are always subject to a considerable amount of settlement and should, therefore, be used only under the most unimportant structures with comparatively small pressures per unit of foundation area. Soils containing materials which render them plastic and greasy are considered very poor foundation material.

Safe Foundation Pressures for Natural Soils.—With the exception of bedrock, nearly all soils are appreciably compressible when subjected to ordinary foundation pressures. The amount of settlement depends upon the character of the material and the intensity of the pressure upon it. Usually the latter is expressed in tons per square foot of foundation area. Decisions as to the adaptability of natural foundation materials and the pressures they will safely sustain without undue settlement, demand mature judgment which has been ripened by personal experience and a knowledge of the results obtaind by others. The amount of settlement permissible for any given case depends, to a marked degree, upon the character of the design and of the materials used in the bridge superstructure. The permissible settlement is, for certain classes of structures, the gauge by which the allowable unit foundation pressures must be measured and final decision rendered.

Reference has been made to the paucity of reliable data relating to the bearing power of soils. In the absence of this data we must be guided almost entirely by past experience. Safe foundation pressures for natural soils are given in Table I. To obtain good results the use of this table should be supplemented by an examination of the foundation material in the abutment and pier pits. Otherwise its use will occasionally lead to unsatisfactory results since any table of this kind can not possibly take full account of widely varying soil conditions.

General Classes of Artificial Foundations.—Artificial foundation materials are divided into four general classes, viz: (1) Compacted soils, (2) grillage, (3) piles, and (4) cribs.

Compacted soil foundations are sometimes used for small drainage structures having comparatively low foundation pressures per square foot. They are produced by treating soft soils and earths to render them more firm and more capable of supporting foundation pressures. Two methods of compacting are in use, viz: (1) A thick, thoroughly compacted bed of sand, gravel, or broken stone is deposited upon the soft soil after excavating it to a considerable depth. (2) A quantity of sand, gravel, broken stone or concrete is forced into the soft soil.

Grillage, as commonly constructed, consists of two or more courses of wooden timbers, laid transversely to each other and firmly drift-bolted together. The timbers may be laid in close contact or they may be separated and additional strength secured by filling the spaces between them with sand, gravel or concrete. Grillage may also be composed of metal beams filled in with concrete or of concrete reinforced by rods or other metal work to give it the desired strength. In order to secure a desired foundation pressure the grillage area is usually much larger than the base area of the substructure unit placed upon it.

TABLE I—SAFE BEARING POWER OF FOUNDATION SOILS FOR ORDINARY STRUCTURES.*

Material.	Safe bearing power, in tons per sq. ft. Minimum.	Safe bearing power, in tons per sq. ft. Maximum
Rock, the hardest kinds, in thick natural beds..	(†)	(†)
Granites, limestones and sandstones, hard grades	30	40
Granites, limestones and sandstones, etc., medium hard grades	20	30
Limestones, sandstones, shales, etc., equal to best hard-burned brick masonry	15	20
Limestones, sandstones, shales, etc., equal to ordinary brick masonry	[illegible]	10
Gravel or coarse sand, in thick beds, well cemented	8	10
Sand, medium, in thick beds, well cemented	4	6
Sand, clean and well drained, confined	2	4
Sand, clean and wet, confined	½	3
Sand and clay combined, in thick beds, well drained, confined	5	8
Clay, firm, in thick beds, well drained, confined	4	6
Clay, firm, in thick beds, wet but not saturated	2	4
Clay, soft, confined	1	2
Alluvial soils, firm	½	1

*Arches, cantilevers, continuous spans, large structures and high abutments should be founded on unyielding material. Special investigations and designs should be made for such structures.

†Any ordinary substructure load.

Piles are more commonly used than any other class or type of artificial foundation material. Their use during centuries past has proved their reliability, especially in soil foundations where excavation to a firm unyielding stratum is unattainable by reason of excessive cost or other practical considerations. Formerly wooden piles were used exclusively, but in recent years reinforced concrete piles have been used to a considerable extent. The types, sizes, methods of preparation, etc., of piles, their proper driving, and considerations entering into the determination of their safe bearing power, although directly related to our general subject of foundations, can not be satisfactorily treated within the space here available. However, it is important to call attention to some common misconceptions of the bearing power of piles.

Bearing Power of Piles.—A pile driven its entire length through soft soil depends for its bearing power upon the friction existing between its surface and the soil surrounding it. This so-called skin friction transfers or imparts to the surrounding soil practically the entire load carried by the pile; the resistance of the soil under its point and the effect of buoyancy are but small in comparison with the load transmitted to it by the substructure. On account of this fact it is improper to drive piles in soft soils at close intervals. A cluster of, say, seven piles driven in close contact with each other can scarcely be considered as developing a bearing power in excess of that developed by three piles properly spaced to transmit their loads to the surrounding soil.

Piles, dependent wholly or in part upon skin friction, produce, by transmitting their load to the surrounding soil, a corresponding soil settlement. It follows, therefore, that the soil underlying the base of the substructure may, in assuming its load, settle out of close contact with the substructure base, thus becoming independent of any foundation pressure apart from that transmitted by the piles.

The Use of Cribs.—Cribs, as generally constructed, consists of grillage bottom frames with box-shaped sides extending upward from them. They are very commonly built at or near the bridge site, launched and towed out to the positions where they are to be sunk. If for a given pier, the final foundation area is covered by a layer of soft soil, it may be dredged prior to placing the crib in position or, in lieu of this, the crib may be sunk upon the soft soil which may be removed by clamshell dredging or by pumping it through the openings in the grillage bottom of the crib. If the foundation area be composed of bedrock, it may be necessary to predetermine its contour and to shape the bottom of the crib roughly to fit it, thus making possible the sealing of the crib against the admission of water preparatory to unwatering it for the construction of the pier within it.

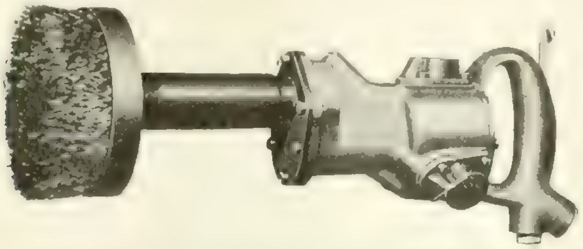
A type of construction sometimes used consists of a piled foundation topped with a wooden crib within which the substructure, pier, or abutment, as the case may be, is built. The piles after being driven are cut off at a uniform elevation that will bring the top of the crib below minimum low water and the crib is floated into its correct position and sunk upon them. Under certain conditions this type of construction is both efficient and economical.

By a closer spacing of the piles under the toe of an abutment than under the heel it is possible to prevent the tipping of the abutment which would otherwise take place if settlement should occur. By varying the spacing a practically uniform load per pile is secured. If perchance, a future settlement of the abutment should occur, this arrangement of the piles would tend to make it uniform.

Generally speaking, engineers do not consider it satisfactory to count upon the transverse strength of a piled foundation as tending to resist the horizontal thrust of arches or other structures producing pressures acting transversely to the direction of penetration of the piles. However, it is occasionally argued that the soil upon the sides of the piles opposite the direction of the pressure can be relied upon to resist that pressure. Granting that this contention is in part true, the question arises as to the extent to which this soil can reasonably be considered as acting. At best, the problem is a complex, indeterminate one. It involves such factors as: (1) To what depth below the base of the substructure shall the thrust be considered as resisted by the piles, the soil being compressible and the piles flexible? (2) Assuming the piles in adjacent rows to be staggered, are more than the [illegible] of piles on the side of the [illegible] opposite to the direction of the thrust active in resisting it? Naturally, any pressure borne primarily by the other rows of piles will be transmitted with little, if any, loss through the intervening soil to the two rows above mentioned. (3) To what extent is the tendency of the transverse thrust effective in disturbing the uniform distribution of the skin friction element on all piles in the foundation? Considering the indeterminate nature of these problems, and considering further that a very slight movement of the superstructure upon its foundation will induce important stresses never considered in the original design, it seems wise to forego all snap judgment and to introduce battered piles in the foundation, even at a considerable increase in cost per linear foot of the piles so driven.

Air Operated Wire Brush for Cleaning Paint and Scale from Metal

Wire brush cleaning of metal surfaces offers an opportunity for considerable saving of time and labor over that required by hand in removing paint, rust, scale and dirt. A wire brush of very rugged design has recently been placed on the market by the Ingersoll-Rand Co., 11 Broadway, New York, for use with its standard No. 6 "Little David" drill. It is a brush with face diameter of 5 in. and is made up of wires of a special heat treated steel which has been found to have very good wearing qualities. It is sturdily constructed and will stand up under severe service. It is manufactured particularly as an attachment for the No. 6 drill (as illustrated), this type of machine being especially suited for work of this nature. The drill has liberal bearings to take up all the end thrust when pressing down on the work; a high speed and very reliable motor, and moreover is of light weight and small overall dimensions. It can be used in sharp corners and other cramped spaces. The whole outfit weighs only 11½ lb. The wire brush outfit is adapted for removing paint, rust, scale and dirt from tanks, steel cars, structural steel and all sheet metal surfaces. It is also useful for cleaning iron, steel and aluminum castings.



Little David Drill Fitted With Special Wire Brush.

Classification and Compensation of Engineers.—The Board of Direction of the American Society of Civil Engineers at a meeting in Houston, Tex., on April 25, endorsed the classification for engineers embodied in the Engineering Councils' Committee report of Dec. 15, 1919 (see Jan. 4, 1920, issue of Engineering and Contracting), as being in its judgment generally applicable to all branches of engineering. The Board of Direction also approved the salary schedule proposed in the report, "not as an inflexible standard, but as indicative of the proper salary relation between the several grades of the classification, as proposing minima for the several grades which under ordinary circumstances are the least that can be considered reasonable and just, and as providing sufficient range between minima and maxima for making adjustments to suit variations in living conditions, kind of work and character of service, and for permitting adequate salary advances within the grades themselves." The Board of Direction further recommends "that copy of its recommendations together with the classification and the salary schedules be transmitted to the membership of the society, to the engineering press and to the American Engineering Council with the recommendation that the classification be adopted in connection with their several employment services.

How Personnel Readjustments Are Handled by Armour & Co.

Mr. W. S. MacArthur, assistant secretary, Armour and Company, Chicago, tells in the May number of "One Hundred Per Cent" something of the company's problems and methods of reducing and readjusting its office force. The following is taken from Mr. MacArthur's article:

The Data.—A close study of the graphic charts and records shows that practically the same number of orders are passing through the order, shipping and billing department as in 1914, and as a consequence the personnel of that department has also been reduced to that basis. With this positive information truly reflecting the state of business, it naturally follows that the general force all along the line is top heavy.

Armed with a statement by departments or divisions, showing the present number of employes as compared with 1914, the office manager is able to impress upon the department heads not only the possibility but the absolute necessity for a readjustment and reduction, and this having been determined the next consideration is who shall be dismissed. This is where the personnel system or whatever card record might be maintained proves its value as it gives all the necessary data in regard to the employe under consideration.

Must Weigh Value of Non-Producing Groups.—The non-producing departments should of course be first considered. How far activities of the Boy Scout Troops, orchestra, glee club, dramatic clubs and other social and welfare organizations, shall be continued must be governed largely by the local conditions affecting the business. For instance, the work of the Scout Troops has an unquestioned value and it would be unwise to abolish their activities completely. On the other hand, it has been clearly proven that a curtailment of expenses to the greatest possible degree arouses the boys to the realization that they must do their part as true scouts, in aiding the executives to obtain the desired results. By this means interest is not only increased but the morale improved as each scout understands definitely the part he is playing in the current events, and this is a feature that should not be overlooked as "the lads of today are the executives of tomorrow." Similar action should be taken with the glee club, orchestra, dramatic club or whatever the company organizations might be, for it brings the matter directly home to each individual and accomplishes a double purpose.

When Diplomacy Counts.—In considering sales and accounting departments, the questions of seniority, efficiency, late and absent record, dependents, and general value to the organization are important factors. As a rule, department managers are willing to co-operate in bringing about the proper results, but, in their desire to effect a reduction in their particular department, frequently overlook things which the office manager must constantly keep before him.

Every organization has to carry certain employes, faithful, steady workers, who have been with the company for many years and have long since attained their maximum capacity. Some department managers would like to release them in exchange for those who are perhaps more capable of development but who have a shorter term of service. However desirable this might be, long years of service cannot be lightly disregarded if the morale of the organization is to be maintained.

Frequently personalities enter into these selections and on these occasions the office manager has the opportunity of demonstrating his skill as a diplomat. There are cases however where employes with years of service are dismissed in preference to others of more recent connection, but special considerations govern these and it naturally follows that each case must be considered apart from all the others.

During the war when so many men were inducted into military service, their places were largely filled by women who are still in industry, and in this readjustment process men are given preference, especially those with dependents. There are of course exceptions and these too are given special consideration.

Reducing and Improving.—It is well to secure from the department manager the names of employes whose services are not up to proper standard, that capable, loyal, conscientious employes, taken out of certain positions, may be used to replace them, thus accomplishing the double purpose of reducing the force and at the same time improving the personnel.

It is necessary in some cases to assign men who have been occupying more or less responsible positions as heads or assistants of subdivisions to work which could be taken care of by others with less experience, but one of the main things to keep in mind in all this readjustment is the necessity for retaining as many as possible of the experienced men who will serve as the nucleus of the larger organization which must be built up when conditions become normal.

In making the selection and rendering decisions which involve so vitally the personal life of the employe, the conferring with department managers and the suggesting of definite lines of action, the office manager brings into play his versatility, and as the connecting link between the executives and the employes, interprets the policy of the organization.

An Engineer Among the Poets

By R. FLEMING,
American Bridge Co., New York City.

A man with technical training may at times have an enjoyment peculiarly his own in wandering through the realms of poetry. A few such instances will be given:

> Swift of foot was Hiawatha:
> He could shoot an arrow from him.
> And run forward with such fleetness
> That the arrow fell behind him!
> Strong of arm was Hiawatha:
> He could shoot ten arrows upward,
> Shoot them with such strength and swiftness,
> That the tenth had left the bow-string
> Ere the first to earth had fallen!

These lines from Longfellow are quoted by Merriman in his "Elements of Mechanics" followed by the problem, "Compute the running speed of Hiawatha in miles per hour, assuming that he could shoot ninety arrows per minute and that when shooting forward he aimed at an angle of 45 degrees with the horizontal." The answer is given, "About 46 miles per hour." "Hiawatha must have been some runner," remarked a student.

> Every moment dies a man,
> Every moment one is born.
> —Tennyson, The Vision of Sin.

It is said that Babage, the inventor of the calculating machine, wrote to Tennyson that if his statement were true the population of the world would be at a standstill, that the true ratio was about one to one and one-sixteenth and that he should change his lines accordingly.

> The stars shall fade away, the sun himself
> Grow dim with age, and nature sink in years.

"Nor is there known to science any natural powers whereby this cosmic doom may be either averted or repaired by exterior reversal," comments one writer. On the other hand another says, "This is a kinematic, rather than a dynamic conclusion, and it is dynamically controverted by the fact that the velocity of light, the velocity of electro-dynamic action, and the velocity of the gravitating time-integral of solar rotation, are each equivalent to the thermal unit of velocity at the center of our system which is indicated by Laplace's principle of periodicity."

> Be not the first by whom the new are tried,
> Nor yet the last to lay the old aside.
> —Pope, An Essay on Criticism.

No progress in engineering, nor in anything else, would be possible if this advice were followed by everybody. Somebody must be the first to try the new.

> For I dipt into the future, far as human eye could see,
> Saw the vision of the world, and all the wonder that would be.
> Till the war-drum throbbed no longer, and the battle flags were furl'd
> In the Parliament of man, the Federation of the World.
> —Tennyson, Locksley Hall.

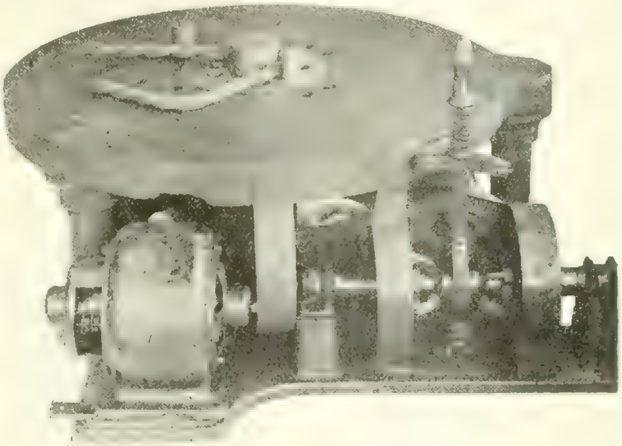
Did the Poet Laureate anticipate by 75 years the League of Nations?

> Soon shall thy arm unconquered Steam! afar
> Drag the slow barge, or drive the rapid car;
> Or on wide-waving wings expanded bear
> The flying chariot through the fields of air.
> Fair crews triumphant, leaning from above,
> Shall wave their fluttering kerchiefs as they move;
> Or warrior bands alarm the gaping crowd,
> And armies shrink beneath the shadowy cloud.
> —Erasmus Darwin, The Botanic Garden.

The foregoing lines by the grandfather of Charles Darwin were written late in the eighteenth century. What a vision of aviation this author must have had! "Warrior band" have alarmed "the gaping crowd" and the time may be near when "fair crews" shall "wave their fluttering kerchiefs as they move."

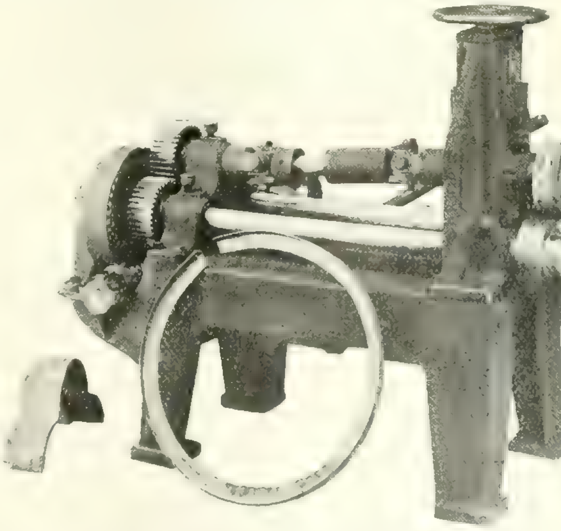
Power Benders for Bending Reinforcing Steel

A new power driven bender designed for bending reinforcing bars, brought out recently by the Wallace Supplies Mfg. Co., 418 Orleans St., Chicago, is illustrated below. The machine has a capacity up to two 1¼ in. square twisted bars at one time, or the equivalent in smaller sizes. With the use of extra high forming pins and rollers, 8 to 10 small bars can be formed at a time. The bars may be bent either to the right or left hand avoiding the necessity of reversing bars in order to make all bends. This effects a considerable saving in time and labor in handling material. The machine also is suitable for the bending of angles, channels, flat and round bars, etc., such as are ordinarily bent on bulldozers. A 7½ HP. motor is required to operate the bender, or it can be furnished arranged with friction clutch pulleys for belt drive. The bender weighs 3,500 lb. and occupies a floor space 6 by 6 ft.



Wallace Power Bar Bender No. 8.

The Wallace Supplies Mfg. Co. also is producing a machine that can be used to advantage for the coiling of reinforcement bars into spirals such as are used for column reinforcement. This machine is designed for bending 2x2x¼ angles cold in 30-in. diameter circles. Lighter sections can be formed to smaller circle. It also is used for bending angles, channels, ties, rounds, squares, or square twisted deformed flat bars on edge, pipe, tubing and special sections. The machine is operated by lever engaging friction clutch pulleys for forward and reverse drive. Rollers can be furnished suitable for any shape or section of material. The upper roller is adjustable by means of a hand screw to secure diameter of coil desired. The machine weighs 1,200 lb. and occupies a floor space of 42 in. by 54 in.



Wallace Ring Coiling Machine No. 3.

The Design of Column and Wall Forms

By E. F. ROCKWOOD

Structural Engineer with Stone & Webster, Inc., Boston.

The design of column sheathing and the vertical members holding horizontal wall sheathing in place is a laborious operation since the resulting equations are of the third or fourth degree, even when the assumption is made that between supports pressure on the forms is uniform. This assumption is permissible since the resulting error is less than 1 per cent.

The matter can, however, be readily cared for graphically and the labor of design materially lessened thereby. To do so proceed as follows:

Let h = head of concrete in feet,
P = pressure at depth h, in pounds per square foot,
S = the spacing of the member in feet,
b = the breadth of the member in inches,
d = the depth of the member in inches,
i = the maximum allowable deflection of the member in inches.
f = the allowable extreme fibre stress in pounds per square inch.
E = the modulus of elasticity in pounds per square inch, and
L = the span in feet.

Then, for continuous members

$$L_f = \sqrt{\frac{20fbd^2}{144SP}} \text{ if strength governs the design} \quad \ldots(1)$$

$$L_e = \sqrt{\frac{2Eid}{45f}} \text{ is the limiting value for L, after which deflections governs the design} \ldots\ldots(2)$$

and

$$L = \sqrt[3]{\frac{Eibd^3}{162SP}} \text{ if deflection governs the design} \ldots\ldots(3)$$

As an example, let it be required to determine the spacings of the horizontal rangers supporting the 2-in. x 6-in. verticals, 3-ft. centers which support the horizontal sheathing of the forms of a retaining wall.

Let is be assumed that E = 1,200,000 lb. per square inch, f = 1,200 lb. per square inch and that i = ⅛ in. or less. Also, that the spans are continuous.

Assume h = 3 ft.

$$\text{Then } L_f = \sqrt{\frac{20 \times 1{,}200 \times 2 \times 6^2}{144 \times 3 \times 420}}$$

$$= 3.08 \text{ ft.}$$

$$L_e = \sqrt{\frac{2 \times 1{,}200{,}000{,}000 \times \frac{1}{8} \times 6}{45 \times 1{,}200}}$$

$$= 5.77 \text{ ft.}$$

From h = 3, Fig. 1, draw a vertical intersecting Curve I at B. Then lay off points $A = h - \frac{L}{2} = 3 - \frac{3.08}{2} = 1.46$, and $C = h + \frac{L}{2} = 3 + \frac{3.08}{2} = 4.54$ and connect them with B.

We now have the diagram in form to use in determining the spacing of other girts. Assume the first girt at the top. Then h = o. The location of the next girt is determined as follows.

1. Draw a line through D, (h = o) parallel to AB.
2. Draw EF parallel to BC.
3. BF = 3.85 ft. is the location of the second girt; and since this is less than L_e = 5.77 ft. the Curve I is the proper curve to use.

Also, for simple span members

$$L_f = \sqrt{\frac{16fbd^2}{144SP}} \quad \ldots\ldots(1')$$

$$L_e = \sqrt{\frac{Eid}{30f}} \quad \ldots\ldots(2_f)$$

and

$$L = \sqrt[3]{\frac{Eibd^3}{270PS}} \quad \ldots\ldots(3')$$

Next, with $\frac{1}{\sqrt{P}}$ and $\frac{1}{\sqrt[4]{P}}$ as ordinate and h as the abscissa in both cases plot curves, having first assumed a relationship between P and h. Fig. 1 shows curves so plotted, assuming P = 140 h, since the pressure of concrete is assumed to be that of a liquid weighing 140 lb. per cubic foot.

To use Fig. 1 the members being assumed as continuous proceed as follows:

1. Assume values for P, b, d, S and f and solve for L_f, Equation 1.

2. Assume the deflection to be allowed as a maximum, and solve for L_e, Equation 2.

3. Take a point on Curve I corresponding to the value of h in question and connect this point to points $h - \frac{L_f}{2}$ and

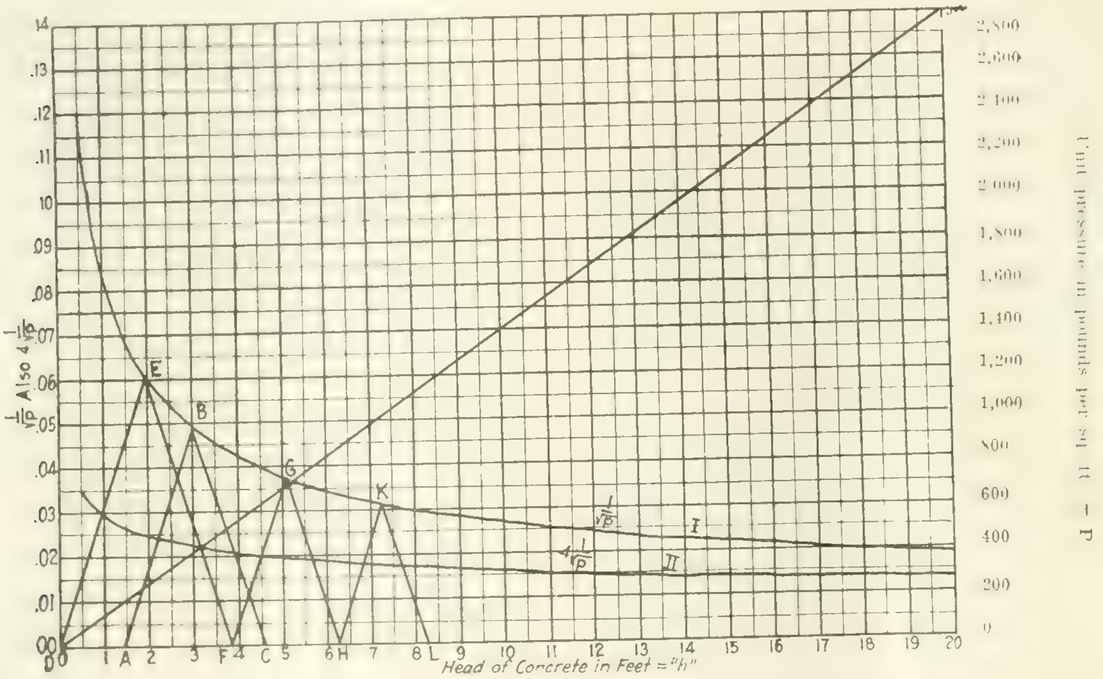


Chart for Designing Vertical Members Subject to Horizontal Pressures.

$h + \frac{L_f}{2}$ on the base line.

4. The span of the member for any other depth h, may now be obtained by drawing through that point on the same curve, lines parallel to the lines mentioned in (3). The distance between the intersections of these lines with the base line will give the span L, if this is less than L_e. If it is greater than L_e repeat the operation, using L_1 Equation 3 and Curve II.

To find the location of the other girts draw a line through F parallel to AB intersecting Curve I at G, through which point draw GH parallel to BC. Then FH = 6.25 — 3.85 = 2.40 ft. is the distance between the second and third girts.

The location of the fourth girt is in a similar manner found to be HL = 2.05 ft.; and others are likewise determined.

Comparative Costs of Small Houses for 1914, 1920 and 1921

At the national conference on the construction industries held at Philadelphia Feb. 15-18 under the auspices of the Industrial Relations Committee of the Philadelphia Chamber of Commerce and the National Federation of Construction Industries, Mr. Daniel Crawford, Jr., an operative builder of Philadelphia, gave an interesting analysis of the cost of the general construction of a typical dwelling. According to his figures a 2-story house of 6 rooms and bath, built in Philadelphia, cost $2,969 in 1914, $8,346 in 1920 and could be built for $6,676 in 1921. These figures are based on an operation of 100 houses. Mr. Crawford's figures follow:

	1914.	1920.	1921.
Ground	$ 500.00	$ 600.00	$ 600.00

STREET IMPROVEMENTS.

	1914.	1920.	1921.
1. Sewer	22.50	60.00	60.00
2. Water pipe	15.00	30.00	30.00
3. Curb (plain)	6.00	16.50	16.50
4. Cartway paving	25.00	90.57	90.57
	$ 68.50	$ 197.07	$ 197.07

GENERAL CONDITIONS.

	1914.	1920.	1921.
1. Plans	$ 1.00	$ 2.00	$ 2.00
2. Survey	3.50	5.00	5.00
3. Building permits and affidavits	5.00	7.50	7.50
4. Water permit (brick and stone)	1.80	1.80	1.80
5. Electric service	....	....	....
6. Gas service	...	4.00	4.00
7. Fire insurance on building material	.10	.10	.10
8. Fire insurance on buildings	1.60	3.87	2.58
9. Plant and tools	5.00	15.00	12.00
10. Sales expense	64.00	176.00	144.00
11. Advertising	32.00	88.00	72.00
12. Office expense	29.40	78.60	65.50
13. Compensation insurance	.....	7.93	6.80
14. Taxes	11.25	25.00	77.45
15. Interest	101.25	263.00	219.40
16. Title company's charges	69.75	150.25	123.75
17. Deed—Acknowledging revenue and recording	4.00	8.50	5.00
18. Expense—Placing first mortgage	20.00	220.00	108.00
19. Expense—Placing second mortgage	23.00	278.00	125.00
20. Supervision	18.00	36.00	36.00
21. Supplies	5.00	15.00	12.00
	$ 395.65	$1,445.55	$1,036.18

CONSTRUCTION.

	1914.	1920.	1921.
1. Excavation	$ 40.95	$ 99.45	$ 93.60
2. Stone masonry	145.54	408.70	354.42
3. Brick masonry	226.25	703.67	659.71
4. Rough carpentry	255.42	955.41	555.67
5. Finish carpentry	266.00	850.00	610.00
6. Plastering	104.61	385.04	269.42
7. Cement work	83.00	258.54	198.76
8. Cut stone	7.70	16.00	16.00
9. Structural steed	11.80	48.47	33.63
10. Roofing and spouting	50.00	120.00	110.00
11. Plumbing and gas fitting	167.00	545.00	442.00
12. Heating	166.00	440.00	368.00
13. Electric wiring	30.00	81.25	65.00
14. Stairwork	37.50	166.00	125.00
15. Labor—general	25.00	50.00	50.00
16. Tile work	5.00	12.00	9.90
17. Iron fence and clothes poles	17.00	30.00	25.00
18. Sheet metal work	[illegible]	105.00	85.00
19. Cabinet work	22.70	56.00	40.00
20. Hardware—finish	11.00	35.00	32.00
21. Hardware—rough	11.00	33.00	24.00
22. Painting and glazing	[illegible]	225.00	215.00
23. Art glass	[illegible]	15.00	15.00
24. Range and connection	21.50	65.00	65.00
25. Gas water heater and connection	12.00	35.00	26.00
26. Parquetry floor	48.60	143.75	129.60
27. Flue lining and crocks	2.10	8.85	8.85
28. Grading—general	[illegible]	6.65	6.30
29. Paperhanging and decorating	12.75	110.00	106.88
30. Lighting fixtures	11.25	90.00	85.00
31. Sodding and seeding	2.43	1.85	4.05
32. Numbering houses	.65	1.00	1.00
	$2.005.15	$6,103.64	$4,842.79

SUMMARY.

	1914.	1920.	1921.
Ground	$ 500.00	$ 600.00	$ 600.00
Street improvements	68.50	197.07	197.07
General conditions	395.65	1,445.55	1,036.18
Construction	2,003.15	6,103.64	4,842.79
	$2,969.30	$8,346.26	$6,676.04
Sale price	3,200.00	8,800.00	7,200.00
First mortgage value	2,000.00	4,400.00	3,600.00
Second mortgage value	700.00	2,500.00	2,000.00

RATES FOR LABOR USED IN COMPILING ESTIMATES.

	Per hour, 1914.	Per hour, 1920.	Per hour. 1921.
Common labor	$0.17½	$0.50	$0.40
Carpenters	.40	1.12½	1.00
Carpenters' helpers	[illegible]	.60	.50
Plasterers	.50	1.25	1.25
Plasterers' helpers	.35	1.10	1.10
Bricklayers	.50	1.30	1.30
Bricklayers' helpers	.35	1.10	1.10
Stone masons	.45	1.30	1.30
Painters	.40	1.00	1.00
Roofers	.40	1.10	1.10
Roofers' helpers	.25	.70	.85
Cement finishers	.50	1.00	1.00
Cement laborers	.20	.60	.60
Tile setters	.65	1.00	1.00
Tile setters' helpers	.40	.80	.68¾
Plumbers	.44	1.15	1.15
Plumbers' helpers	.20	.75	.75
Steamfitters	.36	1.10	1.10
Steamfitters' helpers	.24	.75	.75

COST OF MATERIAL.

	1914	1920.	1921.
Foundation stone, per perch	$ 1.40	$ 4.00	$ 3.00
Bricks, per M.	7.00	20.00	18.00
Cement, per bbl.	1.55	5.25	2.63
Rough lumber, per M ft.	20.00	70.00	46.00
Flooring, No. 1 spruce, per M ft.	30.00	80.00	60.00
Lath, 4 in., per M ft.	3.00	20.00	9.50
Builders' lime, per bu.	.25	.70	.64
Calcine plaster, per bbl.	2.00	6.25	6.25
Sand, per ton	1.30	2.96	2.30
Fibre, per bu.	.25	.35	.35
Structural steel, per cwt.	1.40	5.75	4.00
Tin, per box	8.20	22.00	22.50
Felt, per ton	30.00	110.00	85.00
Pitch, per cwt.	.70	2.00	2.10
Nails, per keg	3.00	7.50	4.75
Sash cord, per hank	.55	1.25	.85
Tile floors, per sq. ft.	.30	1.00	.82½

SUB-CONTRACTS SHOWN BY PERCENTAGE OF INCREASE (ABOVE 1914).

	1914.	1920.	1921.
Hardware (finish)	Unity	218	190
Plumbing	Unity	226	168
Heating	Unity	165	122
Painting	Unity	125	115
Paperhanging	Unity	157	150
Parquet floors	Unity	195	167
Roofing	Unity	140	120
Sheet metal work	Unity	200	150
Electric wiring	Unity	170	117
Millwork	Unity	215	121
Plastering	Unity	268	158
Gas ranges	Unity	200	200
Excavations	Unity	143	128
Rough stone foundation walls	Unity	208	170
Face stone work	Unity	126	90

Mr. Crawford comments on the above costs as follows:

In 1914 it was possible to buy small lots for dwelling house construction on 40-ft. streets for about $500. The price of the same lot today on a 50-ft. street is a little bit more. I say a 50-ft. street because there has been a general tendency in this community to develop on wider avenues, and the land has been laid out by the surveyors or engineers with a view of getting not less than a 50-ft. street, if possible, so that it is difficult today to find a piece of land that is divided up into 40-ft. streets. So that we have taken the same basic value, and merely added the land that is added, and made it $600 for 1920 and $600 for 1921.

The next item that enters into the cost of construction is utilities—the drainage, the water pipe, the curb, the paving—that the builder must pay for. In 1914 they cost him $68.50, and last year they cost him $197.07. This year the rates are the same. Some folks have said that we are going back to pre-war levels. The first important item that we find is the sales expense of 2 per cent, advertising 1 per cent, and office expense about 1 per cent. Generally, that is the total overhead charge of an operative builder. Four per cent represents his selling expense, his advertising and his office expense. The next item is taxes that amounted in 1914 to $11.25, $85 last year and $77.45 this year

The next item is interest. You will notice that when a man starts in to build a hundred houses, it takes a lot of money. He must go to a trust company and negotiate a loan, and, of course, he must pay interest on that loan until he repays it to the trust company. We have predicated that charge on 9 months' interest on three-quarters of the cost of the house, the average operation taking anywhere from 15 to 18 months from the time it is started to the time it is disposed of. The title company charges cover [illegible] and guaranteeing [illegible] ens, [illegible] recording, and all that [illegible] which, [illegible] are perfectly legitimate [illegible] large item is the expense of placing first [illegible] In 1914 we had no difficulty whatever in placing a mortgage of $2,000 on a $3,200 house at an expense of 1 per cent. People were glad to take those mortgages because they were a very good investment. In 1920 the conditions had reversed themselves very much. It was necessary to pay 5 per cent in most cases to place that mortgage, so that the cost of that item jumped from $20 to $220. That condition has been changed this year, and we can place mortgages now at 3 per cent, so that there is run into the expense of building that house a charge of $108. The next item is the expense for placing second mortgages. In 1914 most of the building and loan associations which took the mortgages were in funds, and there was no difficulty in placing that second mortgage by paying the charges of the attorney who represented that association, their solicitor, for drawing the papers, and looking after the settlement, a charge that generally amounted to $23. But the conditions of 1920 changed materially. It was necessary to pay 10 per cent in 1920 for placing second mortgage loans, and that amounted to $278. That has changed, and we can place them today at 5 per cent, so it is $128. Supervision and so on, is estimated at $18, $36 and $36. The general conditions in the construction of the average small dwelling house rose from $395 to $1,445, and now stands at $1,036.

Changes in Retail Food Prices in the United States.—The retail food index issued May 17 by the United States Department of Labor through the Bureau of Labor Statistics shows that there was a decline of 2.7 per cent in the retail cost of food to the average family in April as compared with March. Prices of 43 food articles are reported to the Bureau of Labor Statistics each month by retail dealers in 51 important cities. From these prices average prices are made for each article. These average prices are then "weighted" according to the quantity of each article consumed in the average workingman's family. From January, 1913, to December, 1920, 22 articles of food were used in this index, but from January, 1921, 43 articles are included in the index number. During the month from March 15, 1921, to April 15, 1921, 31 of the 43 articles on which monthly prices are secured, decreased in price as follows: Eggs, 18 per cent; flour and potatoes, 8 per cent; prunes, 7 per cent; nut margarine, lard, crisco, and rice, 6 per cent; butter, 5 per cent; cheese, cornmeal, and navy beans, 4 per cent; cornflakes and canned tomatoes, 3 per cent; plate beef, fresh milk, bread, rolled oats, canned corn, and bananas, 2 per cent; canned salmon, oleomargarine, baked beans, canned peas, tea, coffee and raisins, 1 per cent. The price of chuck roast, hens, cream of wheat, and macaroni decreased less than five-tenths of 1 per cent. Ten articles increased in price during the month from March 15 to April 15, as follows: Cabbage, 21 per cent; bacon, 6 per cent; pork chops, 5 per cent; onions, 3 per cent; sirloin steak, round steak, and oranges, 2 per cent; rib roast, ham, and lamb, 1 per cent. Prices remained unchanged for evaporated milk and sugar. For the year period, April 15, 1920, to April 15, 1921, the percentage decrease in all articles of food combined was 28 per cent.

Summer Course in Model Making at Columbia School of Architecture.—The experiment in training students of architecture with three dimensional models has proved so successful in the regular work of the Columbia University School of Architecture that courses in technique of model making will be given under the summer session, which begins on July 5 and continues for six weeks. The classes in the technique of model making will be given in the evenings so that students who are occupied in work during the day will be able to attend. Harold V. Walsh, instructor in architecture at Columbia, will give the course, which is one of a large number of summer courses in architecture. Courses in shades and shadows, perspective, pencil drawing, advanced design, water color drawing, charcoal drawing, elementary design, elements of design including the application of orders, domestic architecture, antique and life drawing and a course in the fundamental technique of architectural drafting as practiced in the average office are among those offered for the summer semester. Credit toward the degrees in architecture for students who have satisfied the entrance requirements will be given all students completing the architectural courses. The courses are also open to all qualified students without examination.

Personals

W. M. Slopansky has been elected city manager of Belleville, Kan.

F. W. Sefton, assistant city manager of Wichita, Kan., has been appointed city manager of Salina, Kan.

J. E. Caton, public accountant, Kansas City, Kan., has been chosen city manager of Eldorado, Kan., to succeed Bert C. Wells, who recently resigned to assume similar position at Atchison.

R. J. Rich has resigned as county surveyor of St. Louis County, Minnesota, to become district engineer, succeeding George Hughes, resigned. H. T. Hare has been appointed county surveyor to succeed Mr. Rich.

Allan B. Mills, assistant construction manager for the George A. Fuller Co., contractors, New York City, has been appointed director of the Division of Architecture on the New Jersey State Commission of Institutions and Agencies.

A. F. Wickes, architect; A. P. Melton, former city engineer, J. J. Kelley, real estate dealer; W. A. Wirt, superintendent of schools; H. B. Snyder, editor Gary Post; R. E. Rowley, president of the city council, and engineer; P. H. Stevens, president of board of works, and W. P. Cottingham, city engineer, have been appointed members of the city plan commission of Gary, Ind.

J. M. Blythe, heretofore assistant sewer engineer of Hamilton, Ont., has been appointed land surveyor for the city engineer's department. A. R. Hannaford, resident engineer of the Hamilton-Niagara division of the G. T. R., has been appointed to be office and designing engineer, and S. R. Ross, at present with the Frid Construction Co., assistant sewer engineer.

Dr. J. A. L. Waddell, of New York and Kansas City, has been appointed head of the International Commission of Engineers for the great Yellow River Bridge, the most important in the Chinese Empire. He also will advise the Chinese Government on other important engineering subjects. The Yellow River Bridge will be a very long, important and costly structure, built at a remote place, with important materials, under difficult conditions and with very treacherous foundations that demand the highest degree of skill and experience to direct the work and choose from, modify or combine the plans that will be submitted by bridge builders from all over the world.

Obituaries

Edgar M. Graham, a consulting engineer, of Muskogee, Okla., was killed May 11 in an automobile accident.

Andrew F. Ross, an irrigation engineer, died May 10 at a hospital at Provo, Utah, of pneumonia. He was born in Dedham, Mass., in 1865, and came west 20 years ago to superintend the work at the Gunnison Tunnel of the U. S. Reclamation Service.

Edmund T. Perkins, president of the Edmund T. Perkins Engineering Co., First National Bank Bldg., Chicago, Ill., died suddenly May 21 of heart disease. Mr. Perkins was born at Scottsville, Va., in 1864. He was engineer of the United States Reclamation Service from 1902 to 1910, and at the close of his government service he formed the engineering company of which he was the head.

John A. Fairchild, a pioneer contractor of Southern California, died May 11 at his home, 641 South Serrano St., Los Angeles. He was born in the State of New York in 1848 and crossed the plains and mountains to California when he was 18 years of age, first locating in Nevada City. Later he moved to San Jose, then to San Diego, and finally established his residence in Los Angeles in 1883, when he organized the Fairchild & Gilmore Co., afterwards known as the Fairchild, Gilmore & Wilton Co., paving contractors.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Zinc Leaders, Gutters, Etc.—New Jersey Zinc Co., 160 Front St., New York City. Booklet on use of zinc for leaders, gutters, etc.

Tiles.—The Associated Tile Manufacturers, Beaver Falls, Pa. 24 page bulletin devoted to the characteristics of building tiles and methods of production. Contains basic information on ingredients and processes, gradings, sizes, shapes, colors, finishes and nomenclature.

Forms for Concrete Construction.—Blaw-Knox Co., 603 Farmers Bank Bldg., Pittsburgh, Pa. 60 page catalog describing various classifications of Blaw-Knox steel forms and their uses. The text is illustrated by numerous photo engravings of interesting construction operations on which the forms are being used.

Waterproofing of Concrete.—Truscon Laboratories, Detroit, Mich. 28 page technical pamphlet containing a discussion of why concrete requires waterproofing and the properties an integral waterproofing must possess to operate effectively with the natural properties of concrete; specifications for waterproofing mass concrete by integral method; specifications for waterproofing concrete and general masonry structures by means of waterproofing plaster coat; proportions and quantities of waterproofing required.

Alloy Steel.—Joseph T. Ryerson & Son, Chicago, Ill. 96 page book by G. Van Dyke, manager Special Steel Department of Joseph T. Ryerson & Son, on the heat treatment of alloy steels. The chapter headings are as follows: I, Quality (analysis not the only factor); II, Method of Manufacture; III, Elements and the Part They Play; IV, How to Buy and Select Alloy Steels; V, Shop Equipment; VI, Furnaces; VII, Quenching Equipment; VIII, Heat Measurement; IX, Heating; X, Cooling and Quenching; XI, Drawing; XII, Annealing; XIII, Testing Heat Treated Steel; XIV, Case Hardening or Carbonizing; XV, General Remarks.

Steel Sheet Piling.—Lackawanna Steel Co., Buffalo, N. Y. 176 page bulletin containing useful information for engineers and contractors. Among the subjects covered are the uses of Lackawanna steel sheet piling; characteristics of the Lackawanna section; strength of the Lackawanna interlock; types, sections, dimensions and weights; plate sheet piling; driving and pulling steel sheet piling; assembling and splicing; construction of bridge pier cofferdams, protection and retaining walls, bulkheads, cellular pocket type cofferdams, gravity type cofferdams, foundations, etc.; subway and sewer construction; cutting steel sheet piling; protected steel sheet piling; and scores of other important topics. The 337 illustrations contained in the new book include views of seventy projects, some of them the largest ever undertaken, in which Lackawanna steel sheet piling played an important part. Many recent undertakings are illustrated and described in detail.

Roads and Streets Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Should Public Bond Issues Be Delayed Till Interest Rates Fall?

Highway work in some states and counties is being held up because low interest rate bonds can not be sold at par. We wonder whether any society of engineers has investigated the soundness of the reasons that are causing such delays in road construction. As yet most engineers do not take themselves seriously as practical exponents of political economy. Questions of finance they usually leave to others to answer, in spite of the fact that the others may be not only biased but less well informed on the subject.

Interest rates are not less a matter for engineers to study than are unit prices, and many engineers have taken the pains not only to study the fluctuations of interest rates but to analyze the causes of the changes.

Interest is a rental for the use of capital, and, like rental on land, it varies with economic conditions. In general, the interest "yield" on bonds or other mortgages follows the curve of commodity prices, usually lagging a few years behind the price level in its movement.

The following shows the general average of the interest yield on 20 gilt-edged railway bonds:

Year.	Yield. Per cent.
1861	6.5
1862	5.7
1865	6.5
1870	7.2
1873	7.7
1875	6.9
1880	5.2
1890	4.3
1900	3.8
1910	4.3
1914	4.8
1920	6.1

It will be noted that for eight years after the civil war ended, bond interest yields increased although commodity prices had been falling during that period. Commodity prices reached their low mark in 1896, but not till four years later did bond interest yields reach their lowest point.

Based upon this tendency of bond yields to lag behind commodity price movements, we may look for still higher bond interest yields than now exist. Indeed it is probable that three or four years will pass before bond interest yields will begin to decline. Bond salesmen will not concede the truth of this inference, for they wish to encourage the purchase of bonds. Bankers frequently have a similar desire, so that their judgment is also apt to be so warped that they will argue against the evidence of economic history.

It is significant, however, that the most astute managers of large corporations are issuing long time notes and short term bonds that yield 7 to 8 per cent to the investor. The most popular of such means of securing money has been the 10-year coupon note, bearing 8 per cent interest, and redeemable at 105 at any time prior to its maturity. Such a note sold at par yields the investor 8 per cent, but it costs the company about 8.8 per cent, for the company usually has to sell it at about 95 to the brokers who market it.

When the best informed business men are issuing such notes in huge sums, when many foreign nations are selling in America bonds that yield 8 to 8.5 per cent, there is scant hope that an era of low bond interest rates will occur again for several years. Yet many public officials are holding up public works in the hope that 5 and 5.25 per cent bonds will soon be marketable at par. That there has been some market for such low rate bonds has been mainly due to their exemption from income taxation; but, now that there is a good prospect of a change in the income tax law, the demand for tax exempt bonds is decreasing. Moreover it is becoming apparent that the nations of Europe and South America will be coming to this country for huge loans during the next decade. Why, then, should an investor buy the 5¼ per cent bonds of a state, when the 8 per cent bonds of a great nation are to be had? Nothing but tax exemption offers any inducement to choose a low yield state bond, and that inducement vanishes so far as the man of small or moderate income is concerned. Men of large incomes are already heavily loaded with tax exempt bonds, hence the slackening demand for that type of security.

In common with other construction, public works construction has been abnormal for five years [illegible] wages and prices have almost reached the new [illegible] we may look for increasing issues of bonds to [illegible] But an increasing supply of such low yield securities will occur at a time when the demand for them will be either decreasing or, at best, stationary. The effect will be to cause the prices of such bonds to fall, and this in turn will lead to further hesitancy about issuing them. Thus, at the very threshold of reviving construction, we are likely to [illegible] a setback to the revival, unless engineers and other men of vision and knowledge do all in their power to correct the prevalent opinion that a little waiting will result in pre-war interest rates.

Can Counties Do State Road Work More Cheaply Than Contractors?

In Illinois counties are permitted to bid against private contractors for state road work. There may be merit in this plan, provided the taxpayers of the counties are told exactly what profit or loss ensues from work thus done by the counties. The probability is that county taxpayers will never know the true economic results, unless some organization of engineers or contractors undertakes to secure and make public the full cost of road work done by the counties.

When a city, county or state does work by day labor instead of by contract, it rarely happens that the public ever learns the actual cost of the work. Even where adequate cost keeping methods are at first used, the tendency is to abandon them, the excuse for such abandonment being that it costs too much to maintain the cost keeping system. The real reason for the abandonment is usually to be found in the fact that the cost of doing the work is so excessive as not to be complimentary to the public officials in charge of it.

It would be well were engineering societies to advocate laws and ordinances that would insure proper unit cost keeping on all public work done by public forces. No "lack of funds" excuse should ever be permitted to hide from the public the truth as to the unit cost of public work, for without such data the public will never be able to judge whether it is economic to dispense with the services of contractors.

The editors of Engineering and Contracting have found that nearly every attempt to "save the contractor's profit" has ended in failure, and that the day labor method of performing public works is rarely as economic as the contract method. Some engineers are always to be found who doubt the truth of the generalization that greatest economy results when men are paid in proportion to their efficiency; or, if they do not doubt this law of management, they fail to see that it applies as well to the manager of work as to his subordinates. Such engineers frequently advocate day labor work under managers whose income is entirely independent of the cost of doing the work. They assert that contractors are useless middlemen, whose profits are so much loss to the public. They have plausible verbal arguments in favor of this view, but rarely do they offer the only argument that is conclusive, namely, the argument of comparative unit costs. We urge upon such engineers, and indeed upon all engineers, the desirability of requiring the gathering and publishing of unit costs on every job done by the day labor method. It is a duty that engineers owe the public to teach the public how to judge the relative economy of different methods of doing public work.

This can best be done by insisting upon systematic gathering of unit cost data and the publication of comparative costs in such a clear way that no doubt may remain, even to a layman, as to the relative economy of different systems of doing public work.

Price Levels in Other Countries

According to the Federal Reserve Board the wholesale price indexes in April were as follows:

United States	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

These indexes are based on an average index of 100 for the years 1913 and 1914.

The figures for Germany are those of the Frankfurter Zeitung for May 7, the index being based on the prices of seventy-seven commodites, unweighted. As compared with 100 in the middle of 1914, the food price index stands at 1,178; textiles and leather at 2,153; minerals at 1,566, and sundries at 1,633.

The figures for France are those of the general statistical bureau at Paris, based upon forty-five price quotations, unweighted.

The Declining Cost of Living

Exactly a year ago wholesale prices reached their peak and began to decline. Retail prices began, soon thereafter, to show the same trend. According to the National Industries Conference Board, the cost of living for the average wage earner in July, 1920, was 105 per cent above the level of 1914; whereas in May, 1921, it was 66 per cent above the 1914 level. This drop from an index of 205 last July to 166 in May, is almost exactly 20 per cent.

According to the Board, the average wage earner's dollar is spent as follows:

	Cts.
Food	43.1
Rent	17.7
Clothing	13.2
Fuel and light	5.6
Sundries	20.4
Total	100.0

Wyoming Builds Roads Which Are Free from Drifts.—Wyoming is attempting to construct Federal-aid roads which may be used as highways throughout the entire year. This is being accomplished in some parts of the state by maintaining the grade line at an elevation which will insure the roadbed being swept clean of snow. During 6 or 7 months of the 12 in Wyoming there is likely to be snow, which is generally accompanied by wind. Any portion of the highway which is below the surface of the surrounding ground will drift full of snow to a depth equal to the height of any nearby object above the grade, say specialists of the United States Department of Agriculture. By building the grade at an elevation slightly above the surrounding ground and the brush or weeds which border the road, it is possible to have a road which will be free from snow and prevent a soft, muddy roadbed when the snow melts. This can not be accomplished in every case, but on flat or generally rolling country it has been found that snow can be practically eliminated from the roadbed by carefully studying the conditions and placing the grades sufficiently high. In many instances the excavation quantities may appear to be excessive, as where the grade is kept high when approaching a knoll in order to keep the per cent of grade low and at the same time to raise the roadbed sufficiently high over the knoll to prevent drifting of the snow, but slightly greater expenditure in this way at the time the road is built will save large expenditures later to clear away the snow.

Protecting Green Concrete With Canvas Screens.—Light canvas-covered wooden frames 5 ft. wide by 11½ ft. long proved very convenient for protecting the green concrete on a section of the Boston Post Road between Norwalk and Darien, Conn., until the earth covering could be placed. The frame was made of ¾-in. strips 2 in. high, and pieces of lath nailed to the strips over the canvas kept the latter in place. One man handled these sections very readily. The concrete slab was 22 ft. wide but was placed in two 11 ft. strips so that traffic could be maintained during construction.

Pennsylvania Changes Color of Its Road Signs.—Direction signs of the State Highway Department of Pennsylvania, which heretofore were black and white in color, will hereafter be yellow and black, the base of the sign being yellow and the lettering black. The maintenance forces throughout the state are now at work on this change. There is also being painted on each of these signs the mileage to the towns and cities named thereon. This has never been done before in Pennsylvania.

Detroit May Have Municipal Cement Plant.—The citizens of Detroit, Mich., have approved a charter amendment providing for the acquisition of a municipal cement plant and gravel pits. The Commissioner of Public Works may, with the approval of the Common Council, establish plants for the manufacture of bricks and creosote block.

The Passing of the Business Secret

The tendency of the present era is toward co-operation, primarily for the reason that co-operation pays. Incidentally, of course, it has brought a new ethical element into business—the logical connection between the two phases being left as a matter for religious discussion. One form of co operation is the sharing of ideas and of so-called "business secrets" in efficient methods and successful policies. The old formula of business was, "Tell nothing and learn all you can"; the new one seems to be that if you have a good idea, it is worth while to pass it on to your competitor and thus help to raise the level of the whole group. This new vision is by no means universal, but so thoroughly has it been accepted by some of the more progressive companies in electrical and industrial fields that it seems almost as though they kept no secrets of process or policy, but welcomed inspection of every detail. And again without arguing the logical connection, it is an easily established fact that it seems always to be the most successful concerns which hold this policy.

One large copper company of the West is an example of this type of co-operation. It pays, according to the officials of this concern, who state that they have already gained more from suggestions gleaned from others than anyone could possibly obtain from them. A similar spirit is to be observed in certain notable electrical manufacturers, wholesalers, dealers and power companies in this district—and wherever the full light of publicity is welcomed, you will find as a rule that that company is more progressive and more successful than its follows—better liked by competitors and customers as well.

If you are ashamed of your methods, by all means conceal them—but in that case only until you can make them better. If you have something worth being proud of, experience has shown that it will be no loss to yourself to share it with your neighbors.—Editorial in Journal of Electricity and Western Industry.

The Reward of the Man with the "Idea"

The following is a true story of the proceeds to various parties engaged in the development of a chemical enterprise:

To the chemist for the "Idea," together with process and plans	$ 5,000
To the lawyer for legal services in organization	50,000
To the broker for services in floating the new company	100,000
To the owner, net returns in three years	300,000

The chemist, the lawyer and the broker, all three, contributed information. It probably took the chemist longer to see the process through than it did the lawyer to draw up the papers, or the broker to get the subscriptions. But time spent is no gage of the value of professional services. The question is one of intrinsic value. Relatively speaking, the chemist was the parent of the establishment, and the lawyer was its nurse; and outside a divorce court we seldom hear of a nurse who gets all but one and two-thirds per cent of a parent's possessions. There is something wrong in the apportionment of that $55,000. Either the lawyer got too much or the chemist did not get enough. Both contributed professional services. We shall not attempt to bring into consideration at this time of the broker's wage. His work is social rather than professional. He knows men, knows how to get their confidence and to induce them to give up their savings. If the owner knew men better he would not need the broker and if the chemist knew men and their ways better he would get a better fee for his own work.

We need more business in chemistry. If a chemist enters the employment of another man or of a corporation, then whatever he discovers in connection with his employment belongs to his employer. We maintain this, no matter how differently some others may feel. But when he becomes consultant the traditions are against him. He is supposed to work by the hour, like a hodcarrier, at cost plus a bare living. Chemistry has the tradition of being cheap and easy to hire.

There is a strategic reason for this. The chemist comes along first. He is the man with the idea. One can take it or leave it, and it is very easy to pass it by. So few persons want the idea that he soon bids against himself to get it taken up. The lawyer comes in when the money has been spent and trouble looms in the offing. He doesn't worry. Whatever happens he gets his reward. And he has learned how to charge for his services. The chemist has not.

Of course there are a great many poor chemists; men of whom negative results may be predicted almost with certainty. But there are also a great many poor lawyers. As such they are trouble-makers, and the wise man does not retain them. He knows lawyers. But he does not know chemists save once in a thousand times; and he is not wholly to blame for it either. He doesn't know how to go about it to find out the best men available.

What chemists need is Sunday clothes for their ideas; silks and satins and scarlet and velvet for the public to admire and desire. Now the art of presenting ideas so that they are desired and regarded as valuable is called business, whether it has to do with selling goods or negotiating loans or securing subscriptions to an underwriting. Chemists need more business in chemistry to make it pay and to give the profession its proper standing among men.—Editorial in Chemical & Metallurgical Engineering.

The True Spirit of Engineering

A section meeting of one of the national societies was devoted recently to a discussion of certain local production processes. The formal addresses were followed by an open discussion in which practical experiences of members were freely presented. Keen interest was shown in the subject, and toward the end of the discussion a guest requested permission to ask a question which probably related more to psychology than to engineering. He stated that in work for the Government he was frequently required to investigate the processes of some of the food-producing industries. At each plant visited he was told that this particular process was strictly a trade secret of their own and could be revealed only in the strictest confidence. At the next plant of a similar character the management would insist that their process was also strictly their own production and was therefore a trade secret. It often developed that the processes in the two plants were identical, yet each thought that he had a great secret all worked out by himself. In some other cases it was found that a new process had been worked out at great expense which, to the speaker's personal knowledge, had been in use for years in plants in other parts of the country. These manufacturers try to hide their processes from one another, yet any intelligent workman could learn their methods in a few weeks.

Electrical and mechanical engineers seem to take much pride in relating their achievements to one another, and they freely discuss their experiences, as was evidenced by the preceding discussion. The guest wanted to know what there was in the nature of the different professions and businesses that makes some of them so secretive even when their best interests would be served by greater publicity.

A prominnt and successful manufacturer replied that he found that publicity paid. Fellow engineers were glad to know of his improvements and often materially assisted him in further developments by friendly criticism and suggestions. Although other manufacturers had frequently copied his methods, he had found that he always had later developments ready before his competitors had perfected their copies.

This remark led another member to quote from Kipling:

They copied all they could follow,
  But they couldn't copy my mind,
And I left them sweating and stealing,
  A year and a half behind.

A third member stated that the difference was probably due to the ethical principles of different professions and businesses. The early leaders in mechanical and electrical engineering were men of broad vision who had founded the national societies for the purpose of mutual co-operation to advance their respective arts and sciences. It had become a tradition in these societies to share their professional experiences and to tell others of their achievements. Advances in the art are much more rapid when each worker knows what others have done. Hence, every engineer should give his earnest support to his professional organization and should take an active part in its meetings and its activities even at some sacrifice to his personal convenience.

Such discussion as this suggests thoughtful consideration of what should be the true spirit of the engineering profession. It should be the idea embodied in the word "Service"—service to clients or employers, service to the public by the exercise of special professional skill, and service to fellow engineers by freely sharing professional experiences and by rendering help and advice whenever possible.—Editorial in Power

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Promoting the County Road Bond Issue

How a county highway engineer made effective use of publicity in convincing the taxpayers of the necessity of a $150,000 bond issue for road improvement is told by Mr. R. C. Yeoman in a recent issue of the Professional Engineer, from which we quote as follows:

W. S. Canning, formerly county road engineer in Henderson county, Kentucky, has made use of publicity in bringing about the adoption of a bond issue for road-building purposes in a very effective and successful manner.

After taking office as county engineer he began a study of a road system for the county. He began his study with a swing about the county seeking information by direct observation and consultation with the most interested taxpayers. His sincerity and thoroughness soon won for him the confidence and esteem of all of those with whom he came in contact, particularly the staff of the local newspaper. He soon learned the prevailing sentiment and made his plans to meet conditions as he found them.

The primary purpose of his survey and investigation was to enable him to design a system of road construction and repair that not only would carry traffic but in addition would give as much comfort and convenience as the community could afford. He made a complete study of the sources of material, the geographical location of the roads, the alignment and drainage, the traffic needs and the economic and financial relation of the community to these roads.

He concluded that by publicity he would be able to accomplish his job of convincing the public of the necessity of adopting a sound program. Mr. Canning resolved to lay his cards on the table and then sell his proposition on its merits. While he was perfecting his plans he wrote items on such economic subjects as the decrease in the value of the dollar, particularly with regard to construction, which were published in the local paper to prepare the public mind for future judgment.

After he had made a thorough engineering and economic study of the proposition, he prepared a recommended solution to give to the public. No inkling of his plans was given out until he had complete information on every detail. Then, in a full page newspaper report he presented a complete map and a discussion of his proposal which included not only statistics of existing conditions and an outline of needed improvements, but accurate estimates of the cost of his plan for remedying the road conditions. At this point he enlisted the further help of the county judge and the editor of the local newspaper, who both gave him their ablest support. He followed up his announcement with further newspaper publicity and poster advertising until his plan was so thoroughly "sold" that the whole was accepted at the polls without the change of a word or a figure. The plan covered a 5-year program of new road construction and maintenance, embodying a total expenditure of over $150,000.

The care with which his campaign was planned is indicated by the change of nomenclature from a road tax to a road levy to gain the psychological advantage of eliminating "tax."

Another feature worthy of mention was "one minute interviews" from interested taxpayers. Hundreds were asked, "What do you think of the road levy?" The newspaper was glad to have such comment because of its human interest element and the answers were published, to the further benefit of the campaign.

This performance may seem small or large, depending upon the experience and location of the reader. Its execution, however, is by no means unimportant. After the general proposal was published, certain questions came up which were answered in a very complete and decisive manner. Here is a sample of the handbills and posters which were used.

"Squire Utley of Smith Mills asks: 'If we are using all the present levy in taking care of our present roads, how can we take care of the new ones that we build at the end of the five years?'

"'A stitch in time saves nine.' For the past eight or ten years, in fact practically ever since our present rock roads have been built, no systematic effort has been made to maintain them. No ditching has been done, no bridges or culverts repaired, and the roads have at no time been resurfaced. The same thing holds good in regard to the dirt roads. Wooden bridges have been built and rotted down in two or three years, washouts have been permitted to grow larger from year to year, and mud holes have existed from one season's end to the other. Had some of the money which remained in the county treasury at the beginning of the term of the present administration been expended upon resurfacing and ditching the rock roads, building permanent bridges and culverts, and in proper maintenance methods, the present large expenditure of the people's funds in resurfacing roads and rebuilding bridges would not now be necessary. Money saved by penny-wise and pound-foolish policies in the past is now costing the people of Henderson county the same sums twice over in repair and reconstruction work that would have been unnecessary if spent in time. The present policy is to resurface the present rock roads entirely within a period of three years, the building anew in a permanent manner the bridges and culverts throughout the county. If this policy is adhered to, within three years the cost of maintaining the present rock roads and the dirt roads throughout the county will be materially decreased, and ample funds will be available to keep all of our roads in a decent condition. For example, the Corydon Road is estimated to cost $625 a mile per annum for the next three years to put it in a satisfactory condition—after that time the cost of maintaining this road will be less than one-half of this sum. There is where the money will come from to maintain our new roads."

The issue was put up squarely to the voters that it was their adoption of the road levy that would raise the funds to provide a system of adequate highways in the county with their attendant advantages. The plain facts and all the facts were put before them and like any American community, properly lead by honest, capable officials, the people of Henderson county voted "yes" in great majorities, reversing their vote of two years previous.

National Good Roads Essay Contest.—The Highway and Highway Transport Education Committee has announced another national essay contest, open to all pupils of high school grade. The essay is to be on the subject of good roads and highway transport, and the prize is a 4-year scholarship in any college or university. The scholarship, which is donated by Mr. H. S. Firestone, of Akron, O., is valued at about $5,000. This is a repetition of Mr. Firestone's offer last year, which resulted in the awarding of a scholarship to Miss Katharine F. Butterfield, of Weiser, Idaho. United States Commissioner of Education Dr. P. P. Claxton has requested the superintendents of education of the various states to name state committees to pass upon the essays that are written in each of the states, and the best essay from each state will be sent to Washington, where the national prize winner will be decided by a committee to be appointed by the commissioner of education. The essays must not exceed 500 words in length and must be in the hands of the local committees not later than June 15, or the date of the closing of school in each locality.

Pennsylvania Making Progress With Its 1921 Road Work.—Up to May 12, the State Highway Department of Pennsylvania had completed 39.44 miles of durable construction in various parts of the commonwealth. This figure is more than double the total construction for the same period in 1920. Up to the second week of June, 1919, the construction totaled 15 miles. Up to May 12 the maintenance division of the highway department had resurfaced 108 miles of macadam roadway. That figure was reached in 1920 on July 17, while in 1919 it was reached on June 28. The maintenance division of the department on May 12 had completed the surface treatment of 9 miles of roadway. The year 1919 was the banner year for the department in oiling operation, 9 miles being reached on May 24. In 1920 the 9-mile figure was not reached until June 5. The maintenance division is making an effort to complete the oiling of every mile of main traveled highway in Pennsylvania prior to July 4.

Construction Equipment on 21-Mile Joliet-Morris Concrete Road

Central mixing and central proportioning plants are being used by the Powers Thompson Construction Co., Joliet, Ill., on its contract for 21 miles of concrete highway between Joliet and Morris, Ill., a part of the Federal Aid Highway between Chicago and St. Louis.

All grading and bridge work was practically completed during the 1920 season, but owing to inability to secure cement and concrete aggregates in sufficient quantities, no paving was done until the middle of September. By using two outfits, however, the contractor was able to complete approximately eight miles of pavement before unfavorable weather caused them to close the season's work. Work was resumed about April 20 and the daily records of both outfits have been very consistent since then, the total output being at the rate of 1 mile of completed pavement each week.

Dumping Truck Load of Mixed Concrete from Central Mixing Plant.

Entirely different methods of handling materials are being used by the two outfits. On the Joliet end of the contract, a central mixing plant was installed, its location being close to the plant of the Chicago Gravel Co., from which sand and gravel are obtained. At this plant the aggregates are fed directly into stationary mixers by means of chutes from overhead bins. The mixed concrete is elevated into a hopper and dumped into large Packard trucks which haul it to the place on the road where pavement is being laid. Each truck carries four 3-bag batches. The original highway was built of coarse, clean gravel, and the sub-grade, over which the hauling is done, is ideal for heavy truck hauling.

At the other plant located on the E. J. & E. Ry. towards the west end of the contract, materials are unloaded from cars by a locomotive crane into large bins, and from these bins, proper amounts of sand and gravel are proportioned into Western bottom dump, wood batch boxes. The proper number of bags of cement are then added, and the boxes are transported to the mixer on the road by means of a narrow gage railway. Each batch box contains 52 cu. ft. of loose material, this being the proper amount for an 8-bag batch of 1:2:3½ proportions. Two boxes are hauled on each car, the cars being the under-frames of 3-yd. Western side dump cars, which the contractor already owned. For motive power, 12-ton Vulcan steam locomotives are used.

Charging Mixer From Batch Box.

The mixer is a Koehring 28-E paver equipped with a boom and bucket, but without a loading skip or traction. For charging and pulling the mixer, a Bucyrus 14-B crane with full caterpillar tread is used. The crane lifts a full batch box from the car and holds it over the mixer hopper, and upon a signal from the mixer operator, given as soon as a batch has been discharged, the crane operator releases the contents of the box, allowing it to dump into the mixer. The gang at the mixer consists of seven men, in addition to the foreman, as follows: One mixer operator, one finishing machine operator, and one helper; two concrete spreaders and puddlers, one crane operator and one man to assist the train-man in handling the batch boxes. In addition to these men there are, of course, the regular gangs for setting forms, preparing sub-grade and covering and sprinkling pavement.

The maximum day's run with this outfit to date is 847 lin. ft. or 1,694 sq. yd. of pavement averaging 7½ in. in thickness.

Actual Cost of 1½-Ton Truck Operation

Mr. Conrad Bielecky, of Bielecky Brothers, furniture manufacturers of New York City, furnishes an interesting statement of truck operating costs with sufficient description to permit of their intelligent use in "One Hundred Per Cent" for May. An abstract of Mr. Bielecky's article follows:

We have three 1½-ton trucks that are kept busy hauling raw material into the factory, and delivering the finished product to our customers, which are city department stores and outside retail stores that handle willow ware. The trucks go to the railroad freight yards and steamboat piers for willow, rockers, dowel pins and other materials that go into our products.

The willow comes in bundles—that from Japan weighs 110 lb. to the bundle; French willow weighs only 20 lb. to the bundle. This stuff is pretty bulky and we usually carry only about a capacity load.

Wholesale delivery to customers takes up the remaining time of the trucks. With freight conditions as they are today, shipping by freight is practically out of the question, because of the delays and uncertainties in delivery. With our trucks we can deliver anywhere within 100 miles in a day's time.

Most of the articles we manufacture are bulky rather than heavy. A load of rocking chairs, for example, will contain 100 to 105 chairs. As these chairs weigh approximately 18 lb. apiece, the whole load will weigh 1,800 lb., only a little over half the capacity of the truck. But on account of the way our goods bulk, it would be poor economy to use smaller trucks.

GENERAL DATA

Cost of truck, exclusive of tires	$2,714.20
Age of truck at start of period	6 mo.
Cost of operation for year ending Aug. 1, 1920 (depreciation and driver included)	$4,637.28
Days operated	292
Cost per day	$15.88
Total miles traveled	15,229
Miles per day	52.15
Cost per mile	$0.3045
Miles per gallon gasoline	8.1
Miles per gallon oil	182

DETAIL OF COSTS PER MILE OF TRUCK NO. 1 FOR YEAR ENDING AUG. 1, 1920.

Miles run, 15,229.

	Per mile.
Depreciation*	$0.0352
Maintenance and repairs†	.0164
Tire cost (actual)	.0446
Fuel cost	.0371
Cylinder oil	.0033
Total variable expense	$0.1366
Interest	.0077
License	.0010
Garage costs	.0236
Insurance	.0161
Total fixed cost	$0.0484
Driver's wages, $6.23 per day	.1195
Total cost	$0.3045

*Estimated for total life of 77,000 miles. †This was estimated maintenance and repairs. Actual maintenance and repair was $0.0056.

Highway Work Getting Under Way.—Reports to The Asphalt Association, New York, show that during the week ending April 23, 1921, a total of 187 contracts for new roads and streets were awarded, involving an expenditure of $17,857,304. During the week ending April 16, a total of 132 contracts were let, amounting to $14,512,728.

Capillary Moisture and Its Effect on Highway Subgrades

One of the basic necessities in a pavement is a dry, well drained foundation or subgrade. The prevailing practice is to provide drainage by means of open ditches, covered drains, or both, for the removal of free surface or free ground water. Even where this precaution has been taken, many highway pavements have failed because of wet bases. In other instances, in the arid sections of the country, pavements have at least partially failed where drainage was not thought to be necessary, and these partial failures have resulted, as far as could be determined, because of moisture distribution in the subgrades. Why do these highways fail? Why do the foundations become wet and unstable in the face of accepted drainage methods? These are live questions bothering many highway engineers and now causing much concern in connection with highway pavement construction. That capillary moisture may be the cause of some highway troubles and even failures has but recently been suspected. Some interesting data that may bear on this subject are given by Mr. W. W. McLaughlin, Senior Irrigation Engineer, U. S. Bureau of Public Roads, in the current issue of Public Roads, the official publication of the Bureau, from which the matter in this article is taken.

Effect of Capillarity and Gravity on Soil Moisture.—The force of capillarity acts equally in all directions, while the force of gravity acts only in a direction vertically downward. These two forces are at work all the time upon any moisture which may be within the soil. Capillarity is augmented by gravity when working in a direction downward from the horizontal and is reduced by that amount when working in a direction upward from the horizontal.

Table I indicates the relative effects of these two forces:

Table I shows clearly the effect of gravity on the capillary movement of soil moisture, both as to the distance the latter will reach in a given time and the total quantity of water moved. Expressed in round numbers and based upon the figures for the vertical column the moisture had moved downward at the end of 30 days 2½ times as far in the soil column inclined downward at an angle of 15° and 2¾ times as far in the soil column inclined downward at an angle of 30°, as it had moved upward in the vertical column. At the end of 30 days, 3¼ times as much water had moved down the 15° incline and 3.9 times as much water had moved down the 30° incline as had climbed upward in the vertical column.

The table also shows that the quantity of water per unit over the entire wetted length is greater for the columns inclined downward than for the horizontal or vertical columns.

TABLE I—CAPILLARY MOVEMENT OF SOIL MOISTURE FROM A FREE WATER SURFACE INTO A LAVA ASH SOIL COLUMN FOR VARIOUS PERIODS OF TIME, AND THE TOTAL QUANTITY OF WATER MOVED

		Direction moisture moved			
	Time in days	Vertically upward Inches	Horizontal Inches	Downward 15° from horizontal. Inches.	Downward 30° from horizontal. Inches.
Distance moved.	1	[illegible]	[illegible]	24.80	26.20
	2	[illegible]	[illegible]	[illegible]	38.05
	3	[illegible]	[illegible]	[illegible]	[illegible]
	7	[illegible]	[illegible]	63.10	66.25
	15	[illegible]	[illegible]	[illegible]	99.70
	30	[illegible]	[illegible]	137.10	150.10
Water moved in acre-inches per acre	1	[illegible]	[illegible]	[illegible]	0.605
	2	.551	[illegible]	.907	.857
	3	.706	1.008	1.109	1.058
	7	[illegible]	[illegible]	[illegible]	1.764
	15	1.169	2.369	2.722	3.024
	30	1.320	3.58	4.334	5.141

TABLE II—DISTRIBUTION OF MOISTURE IN SOIL COLUMNS BY 2-INCH SECTIONS FROM THE WATER SURFACE.

(Yolo gravel clay [illegible])

	Percentage of moisture	
Distance from water surface	Vertical column. Per cent.	Column inclined downward 30° Per cent.
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	21.28
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	21.00
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	28.70
[illegible]	[illegible]	35.99

That some idea may be obtained of the unit distribution of moisture in a vertical soil column and in a column inclined downward at an angle of 30°, Table II is given:

In Table II the average percentage of moisture per inch in the inclined column is greater by 4½ per cent than that in the vertical column. The per cent of moisture in the end of the column away from the body of free water is 42 per cent greater in the inclined column than in the vertical column. This circumstance is of the greatest importance, because the supporting strength of the subgrade depends upon the percentage of water in the soil.

The percentage of moisture found in a vertical soil column is not related directly to the height above the ground water except at the upper end, and then in only a very general way. The maximum percentage of moisture may be found and, in the clays and loams, usually is found several inches above the water surface. This point is illustrated by Fig. 1.

From the figure it is seen that in the Riverside soil the greatest per cent of moisture is found about 15 in. above the water surface. In the Idaho lava ash about one-half of the soil column is up to capillary saturation. In other words, there would be little difference from the standpoint of moisture content whether the pavement was 6 in. or 24 in. above the water surface.

Distribution of Moisture in Stratified Soils.—Stratified soils of different types are usually found in the alluvial areas and the relative percentage of moisture in the several strata is of interest. Several soil columns were made up of sand, loam, and clay in alternate layers, differently arranged. These columns after having stood for several days were analyzed for moisture. It was found that, at the same height, the several strata contained approximately the same percentage of moisture as a column of one type representing the various soils mingled. Table III gives the results of a typical instance. The made-up soil column has 6 in. of clay on the bottom, then 4 in. of river sand, and then a layer of clay, 6 in. thick, of the same type as the bottom layer. The second column of the table gives the percentage of moisture at various heights in a soil column made up as described above, and column 3 gives the percentage of moisture found at the corresponding heights in a uniform soil column of the type found in the made-up column at the respective heights.

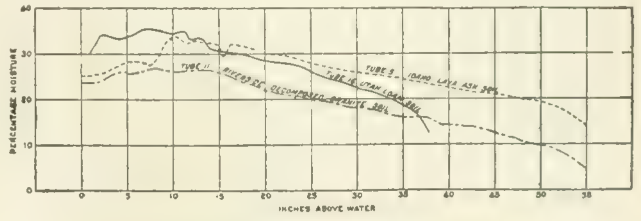

Fig. 1—Relation of Moisture in Soil Column to Water Surface.

In a soil column made up of 16 in. of clay on the bottom and sand on top, the moisture had not moved up into the sand more than 3 in. after standing 20 days. There was only 5 per cent of moisture in the sand, although there was 39 per cent in the top of the clay. Other similar tests indicated the advantage of a top layer of sand or gravel in keeping the moisture percentage low near the upper end of the soil column. The top layer of sand also seems to permit only slow movement of the moisture from the clay upward into the sand. Generally speaking, if the sand or gravel is placed at the bottom and a topping of clay or loam provided, the sand or gravel must be thick enough to prevent the rise of moisture to its upper edge to be effective. While the sand layer may transmit the moisture slowly, the clay or loam will readily take it up. Retardation of the movement within the limits of a few weeks is not of material importance or advantage in pavement work.

Extent and Rate of Capillary Movement.—Questions often arise as to how far moisture will be brought up in different

TABLE III—DISTRIBUTION OF MOISTURE IN SOIL COLUMN OF UNIFORM TYPE AND IN A STRATIFIED COLUMN OF DIFFERENT SOIL TYPES.

	Percentage of moisture.	
Distance above the water.	Made-up column. Per cent.	Uniform column. Per cent.
Average from		
0 to 6 in.	41.39	47.95
6 to 10 in.	13.46	16.10
10 to 12 in.	43.52	40.78
12 to 14 in.	14.89	14.21
18 in.	13.72	12.19

soils by capillarity from a body of free water, and at what rate the water will reach points at various heights above the water surface. Table IV gives some indication of the answers.

The table but emphasizes the fact that the finer the soil texture the greater its capillary power, and it also shows the fallacy of attempting to keep the subgrade dry by shallow drainage or the building of low fills over soil saturated with water or where the underground water table is nearer than 5 or 6 ft. to the surface, unless the soil be sandy. The table shows that in lava ash soil of the type used in the experiment there will be brought to the surface through 5 ft. of soil 1.8 acre-inches of water in a year, and through 4 ft. of this soil there would be brought to the surface in the same time 3.3 acre-inches. Five and one-half inches of water would be brought up through 1 ft. of sand, but through 2 ft. of sand only ½ acre-inch of water would be brought up in a year.

It is difficult to estimate the amount of the evaporation of moisture from below the midpoint of a paved highway. Near the outer edge of the pavement the rate of evaporation may be very rapid, but in the center the moisture would first have to move horizontally to a crack or through 8 or 10 ft. of soil to the outer edge of the pavement. On the deserts of the West the rate of evaporation from a wet soil may be ½ in. per day, and under some conditions even more. The rapid evaporation of the moisture near the outer edge of the pavement might, and sometimes does, result in a dry subgrade at and near the outer edge of the pavement and a wet subgrade in the center. In the heavier soils this would result in a subgrade of unequal supporting power and, through contraction and expansion resulting from unequal moisture content, leave an unsupported outer edge of the pavement or a mushy yielding subgrade center. According to Prof. William H. Burr, the safe-bearing power of a dry clay is 4 to 6 tons per square foot; that of moderately dry clay 2 to 4 tons; and that of soft, moist clay 1 to 2 tons. Hool and Johnson give as the safe-bearing power of quicksand ½ to 1 ton per square foot, gravel and coarse sand well cemented 8 to 10 tons, and clean dry sand 2 to 4 tons. These figures indicate the effect of moisture in the subgrade in its relation to load-bearing strength.

Capillary Syphon May Cause Water-Logging.—Where a highway is built through a country having a transverse slope of 15° or more the movement of moisture down this slope by capillarity is relatively very rapid and extensive. If a sand or gravel stratum is present (especially if it be on top of a clay or other impervious or semi-impervious layer) then the capillary movement of moisture is much more rapid and will extend for great distances. Such soil conditions are not at all uncommon in an alluvial country and afford ideal conditions for the capillary syphoning of water.

The capillary movement of soil moisture from a free water surface is very rapid for the first 48 hours, and for that reason, shallow side drain ditches are not effective in preventing the capillary movement of moisture into subgrades, especially if these ditches are at all near the pavement. Deep drains are not effective against capillary moisture unless placed below the limit of capillary rise of moisture in the soil under consideration.

That capillary moisture has caused soggy, wet subgrades is beyond question and unless effective preventive measures are taken it will continue to cause highway troubles. Just what these protective measures should be and remain within reasonable cost limits has not yet been ascertained.

The data outlined above were obtained from experiments conducted on the capillary movement of soil moisture where the source of the moisture was free water. The capillary movement of soil moisture from a wet soil to a soil containing a smaller percentage of water differs from what has been shown only in quantity. However, the rate and extent of movement of the moisture under the last named condition is relatively so little as to be almost negligible in highway pavements.

TABLE IV—RISE OF CAPILLARY MOISTURE IN SOILS FOR DIFFERENT PERIODS OF TIME AND RATE OF MOVEMENT OF THE MOISTURE.

Distance above water surface.	Light clay loam.		Lava ash soil		Sandy loam	
	Time in days.	Acre-inches per day.	Time in days.	Acre-inches per day.	Time in days.	Acre-inches per day.
12 in.	5/12	0.193	½	0.193	⅜	0.151
24 in.	6½	.0035	2	.116	37	0001
36 in.	55	.0018	6½	.035	....	None
48 in.	219	0001	17	.009	....	.....
60 in.	.....	None	50	.005	....	.....
72 in.	.....	.....	250	.0001	....	.....

Preparing Plans and Making Preliminary Inspections for Roadway Improvements*

By EDWARD E. REED,
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The title of this paper excludes from discussion the preparation of plans and specifications for extraordinary repairs or reconstruction of old worn-out macadam roads, since the word "improvement" usually is applied to new construction only. This interpretation naturally makes the recommendations given below apply chiefly to those localities which do not have a system of highways already constructed such as is found in some of the eastern states. Had more attention been given to the selection of a proper right-of-way, a well drained sub-grade, the elimination of steep grades and bad curves, when these highways were constructed, the errors in construction designated could have been corrected at that time for a fractional part of the cost it now requires.

Conditions Under Which Old Macadam Roads Were Laid Out.—At the time when many of these old macadam roads were laid out and constructed, the automobile had not appeared or was used only to a very limited extent. The land adjacent to these highways was very thinly populated and the value per acre was very small compared to what it is today. Under such circumstances, as a general rule, there were no serious obstacles in the way to prevent the engineer from locating the road about where he desired.

Compare the conditions then with those of today. The present cost of moving a barn or a chickencoop and securing the land occupied thereby is often more than what would have bought an entire farm when the original surveys were made. A great many of our old improved roads were constructed on the old original dirt roads of the country and little effort was made to eliminate bad grades or curves. These old roads were generally so located that few bridges, fills or cuts would be required. To resurface or reconstruct an old macadam road built on such a right-of-way, naturally will require considerable realignment, the construction of new bridges, cuts and fills. The engineers might have been justified then, on account of the traffic conditions, in improving these old roads without the elimination of many of the grades and curves which had to be subsequently eliminated, but such a policy, if followed today, certainly does not produce a very satisfactory roadway.

Lessons to Be Learned from the Old Road Layouts.—In localities where the number of improved roads is only a fraction of those to be improved, the mistakes made by those states that laid out and built their main lines of highways before the advent of the automobile can easily be avoided. Those responsible for the location and construction of new roads in such localities, should make a careful study of what some states are now compelled to do to correct the errors in construction made before the advent of the automobile. The damage done to some of the so-called permanent types of pavements by not correcting these original errors in construction, is recognized much quicker and remembered longer if actually seen and examined. The cost of making a personal examination of the damage thus caused and the methods now being used by some of the eastern states to correct them will in many cases be only a fractional part of the saving made by eliminating these errors in future construction.

The damage that is done to the modern pavement by sub-base waters is seldom recognized, yet in most cases this water does more damage than traffic. This statement may seem radical to those not familiar with this subject, but, when we analyze the causes that produce the failures in bituminous pavements we find that they seldom wear out. On the contrary, the bitumen is decomposed by sub-base waters after which the pavements soon ravel and go to pieces. The truth of this statement then becomes very apparent and the importance of locating highways where a suitable sub-base can be secured is recognized as a very vital factor in proper road construction.

Traffic Conditions Should Be Studied.—It is assumed that before any preliminary surveys are made or plans drawn that the engineer has carefully studied present traffic conditions and roughly estimated what traffic conditions may be expected in the future, and in order to provide for these conditions the

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*Paper presented Feb. 11 at the Highway Engineering Conference at the University of Pennsylvania.

[illegible] of the highway [illegible] that there will be good, adequate connections at these terminals for through traffic, in addition to making satisfactory outlets for the inhabitants adjacent to these terminals. A terminal should not be disregarded or not given the proper consideration if its natural location is such as to make it a favorable outlet and entering point yet does not now have properly constructed highways leading to and from it. Such a terminal will in time acquire properly constructed highways even, if for personal or local reasons, they have not been constructed to date.

Again, it must be remembered that the proportion of local travel to through travel is generally very small unless the highway is situated a considerable distance from any large cities or is not on some well defined route. This through travel should be given due consideration in selecting the route for, if the mileage of the route is considerably increased to accommodate local travel, it naturally increases the cost to the through traffic or, in other words, the minority is favored at the expense of the majority which is not with accord to the theory of our Government.

In making the preliminary surveys for a proposed highway, naturally the shortest line between points to be connected, other conditions being the same, will be the cheapest route to select. However, such a selection may often require extensive cuts and frills, the construction of extra bridges or the installation of a costly drainage system. These other factors naturally will change the location of the highway more or less for it is certainly not economical or good engineering to locate a road where the drainage conditions are so adverse that the life of the pavement is jeopardized thereby regardless of the efforts made to improve the drainage.

Route Having Best Sub-Base and Drainage Preferred.—A careful study should be made of the underlying rock formation and its dip and strike determined. If the rock is well satisfied and has a decided dip, it may introduce a very serious drainage problem. In such cases, the installation of a stone or tile drain on the up-hill side does not always cut the strata that outcrops under the roadbed; consequently, it is not uncommon to find bad local drainage in a sub-grade within a few feet of a well constructed stone drain. In making preliminary surveys in such localites, an effort should be made to locate the road in the localities where the outcropping rock strata is capped by a thick overburden so that water escaping from the strata will be absorbed by this overburden and not collect under the road bed. The valleys usually are the localities where the overburden is the thickest and the most porous.

The life of a pavement laid upon such a sub-base is naturally much longer than that of a similar pavement laid on an improperly drained sub-base, also the cost of the installation of a proper drainage system is thus reduced very much; consequently, it is not always advisable, neither is it economy, to lower the initial cost of construction by reducing the length of the roadway to the minimum if an unsatisfactory or improperly drained sub-base has to be included in such a route. As a general rule, the route that possesses the best sub-base and drainage should be selected unless the cost of construction is increased very much thereby.

Effect of Grades and Curves.—Again, even if the initial cost of construction is somewhat reduced by selecting a route that will have steep grades and bad curves, it is seldom economical to do so, for highways are not constructed for the convenience of pleasure vehicles but are rapidly coming into competition with the railroads in transporting materials. It has been definitely established that the cost of transporting materials increases very rapidly with increase in grades; consequently, there is a constant tax upon the materials transported over such roads by these grades which will soon, in the aggregate, equal and exceed the difference in the cost between the two different routes.

Most engineers are familiar with the tremendous sums that have recently been expended by the railroads to reduce grades and eliminate bad curves, for there is no doubt in the minds of engineers controlling these improvements that the money expended in reducing the grades and eliminating the curves, will be returned in the near future by reduced operating expenses. The same is also true in highway construction, but perhaps not to such a marked extent.

The elimination of bad grades and curves is also very desirable from the safety standpoint for accidents are prone to occur at bad curves or on steep grades. The elimination of these danger factors becomes of more vital necessity as the width of the pavement increases and smoother and more substantial types of pavements are constructed for both of these factors have a tendency to increase the average speed at which automobiles travel. While the governing body seldom is compelled to pay directly for the damage caused by such automobile accidents, yet it should be held responsible for accidents that would have been prevented had these dangerous curves been eliminated.

Both from the viewpoint of cost of transportation and pleasure steep grades and sharp curves are certainly very objectionable and distasteful. In some localities, it may be that some curves and grades cannot be economically eliminated, but a ride from New York to Albany, over the Albany Post Road, certainly will convince almost anyone that such curves and grades should be eliminated in laying out the preliminary surveys for future roads, especially so in localities where the expense for securing the right-of-way is nominal compared to the cost of the construction of the pavement.

There appears to be certain prejudice in some localities against disturbing the surface formations and underlying strata, for it is believed that in doing so the natural drainage of the surface is disturbed, consequently we often find roads following the contour of the surface with very little effort made to reduce the grades by cutting off the tops of the knolls and filling in the valleys. Such an assumption, in the opinion of the writer, is not based upon proven data.

Width of Right of Way.—In many localities it may appear like a useless expenditure of energy and money to insist upon securing a broad right of way. The need of such a right of way is seldom recognized in localities where the country is thinly populated and the towns are small, few and far between. In such localities, the automobile travel is usually very light, but, on the other hand, the cost to secure such a right of way in these localities is also correspondingly low. As the country becomes more thickly populated towns will appear adjacent to the roadway, the auto travel will increase greatly and, in certain localities, it will be even found desirable to widen the pavement to 24 ft. or 30 ft. If additional land has to be then secured, the cost thereof will be many times the original cost. Where towns or cities have developed each side of the highway, the right of way will naturally define the width of one of the principal streets. If this street is narrow, it will be a great handicap to the city and cost a large sum to widen. Regardless of from what angle this subject is viewed, there is little to be said in favor of a narrow right of way except its cost while, on the other hand, the extra cost to secure and maintain a wide right of way is generally very nominal, considering the benefits that may be derived from such a right of way in years to come.

Most Important Factors to Be Considered.—In conclusion, the writer will briefly state the most important factors to be considered in preparing plans and making preliminary inspections for road improvements as they appear to him.

1. So select the route that it will be of the most benefit to those who will use it; that is, it should in addition to accommodating the local inhabitants, make direct connections with other through routes.

2. Select the route that will have the best drained and most stable sub base.

3. The route in which it is possible to eliminate the objectionable grades and curves, at a reasonable cost.

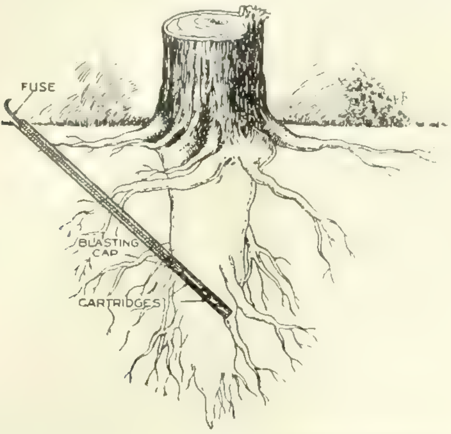
4. Where a right of way can be secured that is of a greater width than is thought will ever be needed.

5. Don't select a route to reduce the initial construction cost if by doing so the drainage has to be sacrificed, grades increased curves, or a narrow right of way retained.

Pennsylvania Has Work Under Way on 619 Miles of Highway.—At the close of the 1920 construction season the State Highway Department of Pennsylvania had under way construction on 467 miles of thoroughfare on which it was not possible to finish the work before cold weather. Since that time and up to May 17, contracts for an additional 152 miles of durable thoroughfare have been let by the department. In other words, there are now in course of completion 619 miles of durable roadway. During the 1919 and 1920 construction seasons the Pennsylvania Department completed 660 miles of durable road. This consisted of either one-course concrete, concrete with a bituminous wearing surface or brick on concrete base.

Use of Explosives in Clearing and Preparing Right of Way for a Highway

Road building, as a rule, involves a large number and variety of operations, all of which must be properly synchronized in order to secure the most economic rate of progress. Furthermore, in road work, the problem of how to reduce the amount of manual labor never ceases to make itself felt. Here the road builder will find many uses for explosives. For example, the output of a steam shovel can frequently be greatly increased by a judicious use of explosives to loosen the ground. A few stumps or boulders which would require hours of arduous manual labor to remove with the attendant delay or inconvenience to other parts of the organization, can be blown up in a few minutes, or the excavation of a wet ditch, a job which labor justly despises, can often be accomplished by means of explosives with satisfaction and profit to all concerned. In the clearing and preparation of the right-of-way, the contractor will frequently find occasion for the use of explosives. Some useful suggestions on this last mentioned phase of road building are given by Mr. Andrew P. Anderson, highway engineer, U. S. Bureau of Public Roads, in a book, "Modern Road Building and Maintenance," published recently by the Hercules Powder Co., Wilmington, Del. The notes following are abstracted from the book:



Properly Placed Charge for Blasting Stumps Having Tap Roots.

Blasting Stumps and Trees.—Many thorough tests covering a long period of time have proven that the cheapest, quickest, and most satisfactory means of removing stumps and large trees from the right of-way is by the use of dynamite, alone or in conjunction with a stump puller. When the stumps are small and the ground loose they can often be removed by the aid of a team of horses, a tractor, truck, or road roller. In swamps and wet ground where stump removal by other methods is almost impossible, satisfactory results are easily obtained by the use of dynamite.

The most economical method of removing stumps with lateral roots is to combine the use of dynamite with a stump puller. The large stumps are blown loose and split by means of charges of explosives properly placed, and then the roots and pieces that remain are removed by the stump puller, a team with block and tackle, or a tractor.

A large job that contains all sizes, types, and ages of stumps can usually be handled most economically by making two trips over the ground. A few stumps that appear easy enough for the puller will always fail to move and will require blasting, while the blown stumps will occasionally leave a root too tough for the team. Therefore, a second shooting of left-overs and a cleaning up of loose pieces and roots is occasionally advisable. The work should be handled in such manner that the blaster and teams do not interfere with each other. This can be done by having them working on different ends of the job.

Different Types of Stumps.—Stumps are divided into two general classes: Those having a heavy, long tap root, with a fringe of lateral or brace roots near the top, like the pine and white oak, and those having large spreading, lateral roots, like the black oak, chestnut, and redwood. To remove these different types properly by dynamite requires slightly different methods. Furthermore, the older a stump is, the more easily it can be blasted, as its resistance to removal decreases with the extent of decay. Green stumps are the most difficult to take out and require from half again to twice the quantity of explosives.

Stumps with Heavy Tap Roots.—There are two methods of placing the charge in blasting tap-rooted stumps.

When the brace roots are small, and it is desired to use a minimum of powder at the expense of a little more labor, the best way is to expose the tap root to a depth of 18 in. or 2 ft., or make a hole with a soil auger, or punch bar that will strike the root about 2 ft. below the surface. A hole is then bored with a wood auger somewhat more than half through the root. In loading, the cartridges should be split, and all of the charge packed into the hole in the wood if possible and the remainder of the hole then filled to the surface with moist clay or other available stemming material and well tamped. Where much work is involved, a boring machine with a power-driven auger can be used advantageously.

Where the boring of the root or the stump involves too much time or expense the stump may be removed by simply placing at least 2 ft. below the surface of the ground, but snug up against and symmetrically around the tap root, two or more charges of dynamite which are then exploded by a blasting machine. Sometimes a single large charge is placed in this manner. This method requires more powder, but less labor, than that described in the preceding paragraph.

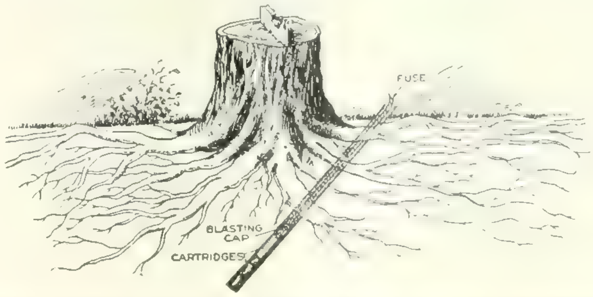
If it is desired to place a heavy charge in a hole or to concentrate the load in the bottom of a hole, an enlargement of the bottom for this purpose may be effected by "springing." To spring a hole a light charge of one-quarter or one-half a cartridge is exploded in the bottom.

When shooting a single hole, fuse and blasting cap are entirely satisfactory, but when there are more than one, a blasting machine should be used, so that all the holes will explode simultaneously, each, in this way, assisting the other.

The depth at which to place charges depends upon the size of the tree or stump and the tap root, the method used for blasting, and also upon the depth of the excavation to the road grade at that point.

The amount of charge to use will vary considerably, due to difference in toughness of roots, the character of soil, wet or dry ground, and other conditions. For this reason no fixed rule can be given for the quantities of explosives to use for various sized stumps. The proper loading will best be determined by practical tests on the ground. The blasting of half a dozen stumps will give a very good line on the most economical amounts to use under the existing conditions.

Blasting Stumps Having Large Lateral Roots.—When blasting stumps having heavy spreading lateral roots, a charge placed under the center of the stump alone might result in merely splitting the stump, the large roots remaining and holding the split pieces. This method is successful with small, lateral-rooted stumps, but in the case of large stumps charges must be placed also under each of the heavier roots, the amounts depending upon the size of the roots, which can be determined with a ¼-in. pointed steel rod or searcher. A blasting machine should be used for simultaneous firing.



Properly Placed Charge for Blasting Stump Having Lateral Roots.

When using a single charge under a small stump of this kind or under an old stump with decayed center, the load should be placed a considerable depth below the butt, so that a substantial cushion of earth will distribute the force of the explosive and prevent mere splitting of the stump.

While a stump removed with a puller often has several times its own weight of earth clinging to it, a blasted stump is free of such encumbrance and is often broken into several pieces. This greatly facilitates subsequent handling and burning.

Removing Stumps of Very Large Size.—In the Pacific coast states, redwood, fir, pine, and cedar trees grow to enormous size. Their roots usually stay near the surface, due, in a large measure, to the wet climate. These stumps can be removed in the same manner as the smaller stumps of similar type.

As an indication of the amount of explosives required to remove these enormous stumps, square the largest diameter in feet. The result will give the approximate number of 1¼x8-in. sticks necessary. This is no fixed rule, but merely indicated a point from which to start. The varying character and condition of stumps and soils, here as elsewhere, cause very different requirements, and only experience can establish the most efficient practice.

Removing Trees with Dynamite.—Clearing the right-of-way for road work frequently necessitates the removal of many trees. The quickest method of accomplishing this is by blasting. In felling trees with dynamite, the placement of holes is the same as for stumping. Larger quantities of explosives are necessary, however, because of the greater weight to be lifted. By judgment in the placing of charges the direction of fall can be controlled. An observance of the wind may be made to render material assistance in both felling and direction of fall. Trees having value for saw stock should not be blasted, as the trunk may be ruined for the saw mill by a split resulting from the explosion.

Selecting the Type of Dynamite for Stumping.—It is frequently the case that in blasting stumps, the road builder uses almost any kind of powder that happens to be on hand. While this may do the work, it is generally not economical, and the dynamite best adapted for stump removal should be selected.

In dense, heavy soils, such as those containing muck, clay, or silt, a low strength explosive is the more satisfactory. A heaving and lifting effect is desired, and the confinement of the charge in such compact soils is so good that the lower strength powders accomplish the work before the escape of the gases. Twenty to 30 per cent strength are best for this work.

In coarse, light, dry soils, such as sand, an explosive is necessary that exerts its force before the gases can get out through the quickly displaced material. For this reason, higher strength powders, 50 to 60 per cent, are required for good results.

Cost of Street Cleaning at Cincinnati, O.

The accompanying tabulation reprinted from the recently issued 1920 report of Fred Maag, superintendent of the Street, Sewer and Catch Basin Cleaning Department of Cincinnati, O., shows the cost of street cleaning operations for the last four years: The costs for 1920 are the highest recorded in the history of the street cleaning department. These increased costs are accounted for by the fact that 1920 was the peak of rising prices in both material and labor. In the month of April, 1920, 2-horse drivers were raised from $3.50 per day to $4.00 per day, an increase of 14 2/7 per cent; the 1-horse drivers were raised from $3.25 to $3.75 per day, an increase of 15 5/13 per cent, while the laborers, helpers, scrapers, white wings and broom gang men were lifted from $3.00 to $3.60 per day, being a level increase of 20 per cent. The 2-horse drivers have had total wage increases in the last four years, approximating 77 7/9 per cent, while the 1-horse drivers and department laborers have secured increases totaling 80 per cent in the same period. The costs were as follows:

	[illegible]		1918	
	[illegible] cost.	Unit cost overhead.	Unit cost.	Unit cost with overhead.
[illegible]	[illegible]	.268	.120	.274
[illegible]	[illegible]	.526	.332	.633
[illegible]	[illegible]	.515	[illegible]	.613
[illegible]	[illegible]	.247	.313	.360
[illegible]	[illegible]	.282	.264	.305
[illegible]	[illegible]	.162	.138	.155
Gutters after flushing, squares.	.140	.157	.167	.187

	[illegible]		1920	
	Unit [illegible]	Unit cost overhead.	[illegible] cost.	Unit cost with overhead.
[illegible]	[illegible]	.284	.151	.325
[illegible]	[illegible]	[illegible]	.463	.853
[illegible]	[illegible]	.638	.461	.793
[illegible]	[illegible]	.380	.410	[illegible]
[illegible]	[illegible]	[illegible]	.320	.368
[illegible]	[illegible]	.199	[illegible]	.288
Gutters after flushing, squares.	.169	[illegible]	.194	.216

Widths of Roadways and Sidewalks in Municipalities

The securing of adequate roadway and sidewalk widths is one of the most important problems in the modern city. A suggestive report on this problem was presented April 29 at the convention of the National Highway Traffic Association by Mr. H. J. Fixmer, paving engineer, Board of Local Improvements, Chicago. The report practically in full follows:

It is quite obvious that the width of the street is to be determined by the use to be made of it. The proper width of street is a summation of the width of roadway, width of sidewalks and extra or reserve width. The extra or reserve width is set apart for parkways, to add beauty and comfort, and to provide for future expansion of roadway and sidewalk width. In the typical city where the width of street is fixed and defined by buildings, the width of roadway and sidewalk must be carefully proportioned. Where these widths prove inadequate to accommodate the traffic the street must be widened by condemnation. Where this cannot be done, because of physical, legal or economic conditions, the traffic must be restricted and regulated by police power.

Width of Roadway.—The width of pavement of roadway is determined by traffic needs, by tradition, by esthetic requirements or by limitations of site or cost. In the city the value of the pavement to the users is of paramount importance. The pavement must prove safe and comfortable to use, must be truly economic, must present an agreeable appearance, and must accommodate the abutting property and the character and amount of traffic using it.

The realization of the above qualities is intimately affected by the factor of width of roadway. Owing to the great increase and diversified use of motor vehicles, the fundamental basis of pavement design today is to fulfill the needs of the traffic; to serve the users of the street in an efficient manner. The following quotation is from a paper presented before the 1920 annual meeting of the American Society of Municipal improvements by Mr. Robt. Hoffman, chief engineer, Department of Public Service, Cleveland, O.:

> The determination of roadway widths may be considered from two different points of view. One is from the view point of appearance, governed by rules of proportion, or by making provision for predetermined widths of sidewalk strips or for lawn and parking spaces. The other view point is that of traffic accommodation.
>
> The first view point applies principally to parkways, boulevards and certain classes of residence streets where beauty and proportion largely control the design rather than economy and utility. Making the roadway from 50 to 60 per cent of the street width between property lines will, in many cases, satisfactorily suit conditions. The design of the planting strips and lawns will, however, nearly always control the width and arrangement of the paved roadways. Even here the expected traffic should receive consideration, but its subordination to other conditions may be perfectly logical and free from criticism.
>
> Consideration of roadway widths from the second view point, that of traffic accommodation, obviously applies to the greater number of cases, and should be the prevailing point of view when considering any basis of design or the standardization of widths.

Kinds of Traffic.—There are five general classes of traffic using the city street. These are: pedestrian, horse drawn, motor driven, street railway and stationary traffic. Stationary traffic consists of vehicle loading or unloading merchandise, and vehicles, mostly motor driven, appropriating the public space for parking. Since all classes of traffic have the common right to use the street, the street should be designed to afford each class the maximum of comfort and safety without abridging or destroying the rights of the other classes.

Effective Width.—The effective width of roadway is that part available to moving traffic. The effective width of roadway is affected by the presence of street railway tracks, by the provision for parking vehicles, by the custom or necessity of backing vehicles against the curb to load and unload material, by slippery surface, by excessive crown of surface, by accumulation of snow and refuse and by uneven or worn out pavement surface.

Requirements of Traffic.—The width of roadway required for traffic is a function of the necessary clearance of the width and permissible speed of the vehicles and the volume or amount of traffic. The relation between roadway width and width of vehicle, for each line of traffic, (standing or moving) is given by the following formula:

$$W = B + C + \frac{S}{10} \quad \ldots\ldots (1)$$

S being the permissible max. speed (in miles per hour) of the vehicle traffic.

W = required width of roadway for one line of traffic parallel to the street axis (in feet).

B = width of vehicle (overall) in feet.

C = lateral clearance factor, varying from ½ to 1.

Thus in order to fix the width of roadway to accommodate the character of traffic the widths, particularly the allowable maximum, of all vehicles, together with the permissible speed must be known. Where vehicles stop or park parallel with the street axis the required width from the formula is overall width plus one half foot. Where vehicles are permitted to park at an angle or back against the curb to handle goods, the width must be increased from six to twelve feet, over the width needed when standing parallel with the curb. The space to be provided for parking or so called stationary traffic must be definitely settled.

To determine the effective width or width to be kept open for moving traffic, we must know the number of moving lines of traffic to provide for.

The distance required to stop a motor driven vehicle equipped with proper brakes, road in good condition and driver alert, is determined by the following formula:

$$D = \frac{S^2}{10} \quad \ldots\ldots (2)$$

D = distance in feet to stop vehicle.

S = speed in miles per hour (maximum permitted).

The headway required for fast moving vehicles varies with the maximum speed, the factor of safety assumed (to allow for poor brakes, possible slipperiness, time for driver to act), and the length of the vehicle.

$$H = DF + V \quad \ldots\ldots (3)$$

H = Headway in feet.

F = Factor of safety (ordinarily equal to 2).

V = Length of vehicle in feet. V is important only at low speeds, and varies from 10 to 30 ft. depending on the kind of vehicle.

*The maximum number of vehicles per hour per line of moving traffic is given in the following formula:

$$N = \frac{5280\ M}{H} \quad \ldots\ldots (4)$$

N = Max. number of vehicles per hour per line of moving traffic.

M = Assumed average speed in miles per hr.

The number of lines of traffic to be provided for should be based on the future use of the street. A traffic census is of little value unless carefully interpreted, and then only is important as an aid to judgment.

The total width of roadway to accommodate the character of traffic using a given street is the summation of the number of traffic lines required for moving and stationary traffic.

A given width reaches its greatest capacity when speed is uniform or average speed approaches the maximum speed. This ideal condition is never reached and closely approached only on long stretches of open country road or certain boulevards.

On the city street the speed is restricted to a low average, due to frequent cross traffic, presence of car tracks, and mixed character of traffic. To accommodate an increase of traffic the maximum speed and even the average speed must be reduced. A double track street railway requires a width of 20 ft. for safe and rapid operation. On streets other than those carrying car tracks the requirements of rapid vehicle traffic indicate a minimum width of 20 ft. for the rapid moving middle traffic.

Regulation of Width and Speed of Vehicle.—The necessary width of roadway for vehicle traffic is a function of clearance, width and permissible speed of vehicle as shown in Formula I. The following table shows necessary width for each line of traffic. $(W = B + \frac{1}{2} + \frac{S}{10})$.

TABLE I—RELATION OF ROADWAY WIDTH TO WIDTH AND SPEED OF VEHICLE.

	Overall Width of Vehicle (in feet)					
Permissable speed of vehicles in miles per hour (min.)	6	6½	7	7½	8	8½
	Width of Roadway per Line of Traffic.					
Parked or standing (parallel to curb) (stationary)	6½	7	7½	8	8½	9
5 (miles per hr.)	7	7½	8	8½	9	9½
10 (miles per hr.)	7½	8	8½	9	9½	10
15 (miles per hr.)	8	8½	9	9½	10	
20 (miles per hr.)	8½	9	9½	10		
25 (miles per hr.)	9	9½	10			
30 (miles per hr.)	9½	10				
40 (miles per hr.)	10					

Apart from consideration of pavement damage due to impact, tire equipment, etc., the speed must be regulated from the standpoint of public use, safety and economy. It appears that 10 ft. should be the proper width for each line of rapid traffic, and 8 to 9 ft. for side or slower moving traffic. Thus a truck measuring 8½ ft. overall would be limited to a maximum speed of 10 miles per hour, and should not travel along the middle strip reserved for rapid traffic.

It seems the general consensus of opinion that, until demonstrated uneconomic, the width, length and height of vehicles should be limited to 8 ft., 24 ft. and 12 ft., respectively

Economic Value of Width.—City pavemenss are expensive, and it is wise to carefully determine adequate width. Pavement cost varies from 50 ct. to $1 per foot in width per lineal foot, or $3,500 to $5,000 per mile per foot in width. It is for this reason that the maximum width should be a minimum to accommodate the needs of the traffic and abutting property. Streets should not be paved too wide where use does not demand it. Arbitrary standardization is wasteful. The regulation of width of vehicle is certainly justified in view of the added cost to accommodate a small percentage of extra wide trucks. The loss occasioned by congestion, detours, restricted business and so forth, due to an inadequate roadway should be determined. This loss, when capitalized, indicates the sum that can be wisely spent to increase the roadway width or construct new trafficways adjoining, above or below the present street surface.

Sidewalks.—The main purpose of the sidewalk is to accommodate the foot or pedestrian traffic. Other uses are incidental and can be ignored in determining the proper widths. The width of the sidewalk is often reduced by the presence of poles, hydrants, receptacles and building encroachments, usually stair entrances. The arbitrary, or "practical" rule for sidewalk widths on each side of the street, is given by the formula: $Sw = L \times 2$. Five S.w. = sidewalk width in feet on each side of street. L = number of lines of traffic provided by the roadway. The traditional method of determining sidewalk width is to make Sw from 8 to 20 per cent of the total street width. A line of pedestrian traffic is universally taken as 2 ft. in width. It is obvious, therefore, that the effective sidewalk width should be a multiple of two.†

In large cities the matter of adequate sidewalk width is vitally important. A formula can be developed for sidewalk width similar to the one used for roadway width. The width for one line of moving pedestrian traffic is taken as 2 ft. This includes allowance for clearance at the average speed of ½ to 3 miles per hour. The distance apart (headway) is determined by speed, or rather degree of congestion, and comfort.

The following formula shows capacity of walk per 2 ft. of width at various rates of travel for various distances apart:

$$N = \frac{5280\ M'}{H'} \quad \ldots\ldots (6)$$

In which N′ = Max. number of pedestrians per hour per line or traffic (2′ width).

M′ = Average speed in miles per hour.

H′ = Headway, or distance between bodies (2 feet) for body.

Sw = Width of sidewalk in feet.

T = Total number of pedestrians passing per hour.

$$Sw = \frac{2T}{N'} \quad \ldots\ldots (7)$$

In a congested street, due to frequent interruption by cross traffic, etc., with an average speed of 1 mile per hour and distance between pedestrian of 6 ft., we find $N' = \frac{5280 \times 1}{(6 + 2)} =$ 660 persons per hour per 2 ft. of width, or 330 per hour per foot of width. This is approximately the maximum, since the clearance (for comfort) varies nearly directly with the speed.

City Planning.—The importance of street and roadway widths is now quite well understood by students of city planning. The proper development of property as well as the

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*See article by H. J. Fixmer in Engineering and Contracting Apr. 2, 1919, page 328.

†See article by H. J. Fixmer in Engineering and Contracting, Nov. 22, 1911, page 562.

[illegible] ROADWAY, SIDEWALK AND STREET WIDTHS

[illegible]	[illegible] vehicles.	Probable width vehicles.	Maximum speed allowed.	Probable average speed.	Max. No. vehicles (per hour) (no parking) °	Roadway width.	Sidewalk width (each side).	Pkwy or reserve (each side).	Min. total street width (bet. buildings).
[illegible]	16	7	20	15	1600	24	6	9-12	‡50-60†
[illegible]	16	7	20	15	2400	30	6	12	66†
[illegible]	[illegible]	7	30	20	3270	56	10	22	120
[illegible]			20	10	2200	40-48	12	28 to 24*	120*
[illegible]			20	10	3180	60	16	0 to 14*	92 to 120
Retail business street (car line).	16	[illegible]	15	5	3500	80	20	0	120
[illegible]	[illegible]	[illegible]	10	3	1440-2160	44 to 68	10	0	64 to 88
[illegible]	14	[illegible]	30	20	1200	20	4	16	60†

*[illegible] allow for future traffic [illegible]

†Where zoning laws are in effect and character of street is settled. Otherwise require reserve space by establishing 30 ft. "build- [illegible]

‡[illegible] frontage street for local [illegible] allowed.)

°Where parking is permitted reduce capacity to correspond with number of lines of moving traffic.

enjoyment of community life, is dependent on the street layout. Let us trace the history of street widths in the average American city. The universal street and road width east of Ohio is 66 ft., an arbitrary unit based on the "surveyor's chain," this unit being adopted to facilitate computation of areas in terms of acres, rather than from any consideration of traffic needs. This traditional or "standardized" width is inadequate in many places and wasteful in others. Many streets are laid out with the width based on wilful expediency or vague imagination, no thought apparently being given to the needs of traffic, accessibility, need of parkways, or future use of the street.

The general rule for adequate street width is given by the simple formula W = WR + Ws + Wp + Wg in which

W = total width between buildings.
WR = necessary width of roadway.
Ws = necessary width of sidewalk.
Wp = width of parkways.
Wg = reserve width or width necessary to widen roadway and sidewalk when character of street and property changes. Very often Wg is taken equal to Wp, the parkways being absorbed later on in the roadway and sidewalk space. In some cases Wg is laid out between the sidewalk and so called building line. This is good practice where legal, and later on, enforceable. (See Table II.)

The following table is submitted to show approximate roadway, sidewalk and street widths required for modern traffic for usual types of streets, in the average municipality. This table does not represent an attempt at standardization. It appears here to indicate the proper method of determining total street width, which should, if possible, be secured when the street is originally platted:

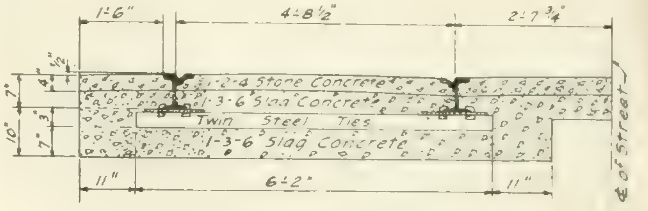
It is still the general custom to determine roadway width on the basis of limitations of site and cost. While this method may be warranted in a few cases, it should be generally discouraged. Some cities have attempted a general standardization by assigning ratios to the roadway or sidewalk width. Usually the roadway width is established at 40, 50, 60 or even 70 per cent of the total street width. There should be no general standardization of roadway or sidewalk widths. As stated before, the width should be an expression of the use of the street or the needs of the traffic and abutting property. Each street should be studied not only alone but in connection with the general street plan, and widths adopted to fit its use. City planning, with its provision for zoning, will greatly assist in defining the character of the street and thus enable us to design street, sidewalk and roadway widths more efficiently in the future.

Pennsylvania Road Contractors Urged to Employ Local Labor.—The State Highway Department of Pennsylvania has urged contractors engaged on road construction projects to employ local labor rather than import the labor needed. State Highway Commissioner, Lewis S. Sadler, issued the following statement:

"A survey of the state discloses the fact that in almost every community there are large numbers of unemployed men and that this number is increasing weekly. The highway department is anxious to relieve this situation insofar as the contracts under its direction will afford employment. In view of the fact that practically all communities are affected alike and that there is available a local supply of labor for all our existing contracts, our contractors are being urged to seek the services of men living in the community in which they are operating rather than to import labor from a distance; and especially are they being urged not to interfere with such labor as is, or will be, employed on the farms of the commonwealth."

Method of Constructing Concrete Paving for Street Railway at Birmingham, Ala.

During the past 10 years the Birmingham Railway, Light, & Power Co. has laid approximately 20 miles of single track equivalent of concrete pavement. The design adopted for this work is shown in the city, reproduced from the Concrete Highway Magazine, from which the matter in this article also is taken. The section shows the construction on Tuscaloosa Ave., where two miles have just been completed. A feature of this track construction was the "twin" steel ties spaced 6 ft. on centers. These consist of two 3-in. steel channels riveted to two plates 13 by 36 in. by 5/16 in. clamped to the base of the rails. Seven-inch 150-lb. grooved rails were used. On other work creosoted wood ties spaced 3 ft. on centers are sometimes used.



Cross-Section of Concrete Street Railway Pavement on Tuscaloosa Avenue, Birmingham, Ala.

On the Tuscaloosa Ave. job, while concrete was being placed the track was supported by means of wedge shaped wood blocks. Final adjustment of track to line and grade was made just previous to placing concrete and was checked up behind the mixer to make sure no settlement took place when the mixer passed over it.

Two-course construction was adopted, the total thickness of the concrete being 17 in. The base course is 13 in. and of a 1:3:6 mix; the top course is 4 in. and of a 1:2:4 mix. Basic slag, abundant in this district, was used as coarse aggregate for the base. A good grade of limestone was used for the top course. Clean, coarse sand was obtained from pits near Montgomery, Ala. The concrete was well tamped under the plates, rails and ties to avoid air pockets which might cause slight settlement. Hand floating was used to finish the pavement. With the grooved rails used on Tuscaloosa Ave. an unusually smooth riding track is obtained. No transverse joints were placed in the concrete except when concreting was stopped for some time.

In 1917 several blocks of concrete pavement were laid without joints. This is now 2½ years old and is giving such excellent service under heavy traffic that it has been decided to eliminate joints on all future work. Some few transverse cracks have developed, but these are so fine as not to require filling with tar.

Where double track is being paved, as on Tuscaloosa Ave., one track is paved at a time with crossovers provided to divert the cars to the other track, so as not to delay traffic. On the first track paved, the concrete for the base course is placed to a distance of 18 in. outside the rails in order to give the track a firm support during the period of its use before the other track has been paved. The top course is laid only between the rails. In this way the rails serve as forms and no longitudinal joints appear on the surface. The other track and the space between the tracks are then paved in one operation. The municipal pavement between track and curb is then laid by the contractors for the city. The cost of this work for a distance of 18 in. outside the outer rail is borne by the railway company.

Recent Practice in Construction of Crushed Stone and Gravel Roads in Pacific Northwest

Developments in the surfacing of highways with crushed stone or gravel as practiced in the Pacific Northwest are reviewed in the current issue of Public Roads by C. L. McKesson, Senior Highway Engineer and A. F. Morris, Highway Engineer U. S. Bureau of Public Roads. The notes following are taken from their article:

Many miles of crushed stone or gravel surfacing are now under construction. Due to a lack of water in most localities where this type is being built, water has been used on only a few projects and rolling is seldom resorted to. The general practice now in this section is to use much finer material than heretofore, both in bottom and top courses. The maximum size of material used is 2 in., and on many of the most satisfactory pieces of construction 1½ in. was fixed as the maximum. The ease with which such a surfacing may be maintained and the smooth, uniform roadway resulting seem to justify the small additional cost involved in producing the finer material.

Sizes of Crushed Stone or Gravel—The more recent specifications for crushed stone or crushed gravel surfacing usually require the material to be screened into two bins, one receiving the material from 2 in. or 1½ in., the maximum size, down to 1 in. or ⅞ in., and the other containing the finer material. The material is spread in 2 courses, each approximately one-half of the total thickness, but the exact thickness is regulated in such a way as to use all of the material between 1½ in. and 1 in. (or ⅞ in.) for the bottom course and the finer material for the top course. The base course is usually spread about 500 ft. in advance of the top course, but this is varied in order to prevent the overflow of either of the bins.

The results obtained under these specifications have been satisfactory, but it has been noted that the stone from some quarries has set up into a smooth, hard roadway much more quickly than that from others. In some cases stone which screening and abrasive tests indicated as being of superior quality did not form as satisfactory road material as a softer stone on which a rather adverse report had been made by the testing engineer. It has been demonstrated that a small amount of soft stone in a quarry provides a binder which is far more desirable than earth or clay, which it is sometimes necessary to add to the base where the material is a particularly hard clean basalt.

On one project in Central Oregon the specifications call for crusher-run material of a maximum size of 1½ in. laid in one course of 5-in. thickness and leveled up with a top course of approximately 1-in. thickness. The results are not as satisfactory as on other projects where the material is separated into two grades and laid in two courses. When laid in deep courses, the material does not compact as well as when laid in lighter courses and the operation of spreading and dragging the stone tends to sift the screenings to the bottom and leave the larger fragments on top—eactly the reverse of the ideal condition.

In some specifications an attempt is made to specify percentages of material passing a series of screens between the maximum and minimum sizes. There appears to be little or no justification in practice for this attempted refinement. A gravel or broken-stone type of surfacing is at best only a light traffic surfacing and every effort should be made to use suitable materials locally available. In many cases splendid pieces of work have been constructed with material which would not comply with a specification requiring an ideal grading with a minimum percentage of voids. The maximum size should be specified at 1½ or 2 in. The maximum and minimum percentages of sand should be specified between liberal limits. The proportions passing and retained on a ⅞-in, or 1-in. screen should also be specified. These proportions can easily be checked on a large scale during the progress of the work by noting the relative output from each of the bins. The various pits should be carefully examined and average grading of the material, apparent cementing qualities, percentage of oversize particles and availability of material should all be considered in the selection of pits. The best material that can be obtained within reasonable costs should always be selected. In some cases it will be found necessary to use gravel little of which is coarser than ¾ in. or 1 in., and some very satisfactory results have been obtained with such gravel, which of course requires no separation of sizes.

Crushed Gravel Most Satisfactory for Dry-Built Roads.—Where surfacing is laid without water and without rolling, crushed gravel has generally been found to be the most satisfactory material. The selection of gravel pits requires care and experience on the part of the engineer. As a rule any gravel which is found cemented together in the pit will form an excellent road metal when crushed and properly laid, while gravel which lies loose in its natural state, as in beds of streams or which carries a large amount of sand, can not be expected to set up rapidly when deposited on a road, though there have been some exceptions to this rule. The gravel, though lying loose and free in the bank, may carry enough soft granite or other soft stone to form a natural binder when crushed, but as a general rule, unless the material is found well cemented in the pit, it will not prove satisfactory as a surfacing material where the oversize gravel and excess sand is screened out and no crusher used. Such material will not compact into a good wearing surface in dry weather without the addition of clay or earth binder. Where such binder is used the results usually appear to be satisfactory in the summer, but, when the clay which acted as a binder in August becomes a lubricant in January, the results are apt to be far from satisfactory. It is very desirable to crush oversize material rather than to screen and waste it. Any gravel which contains 15 to 20 per cent of oversize material will justify the use of a crusher.

A number of projects have been constructed with gravel spread in two layers each of approximately one-half the total thickness, the material in both the top and bottom courses being required to pass a 1½-in. screen. In Washington it has been the general rule to specify "one-course" gravel of a maximum size of 1½ in. While the specifications permit laying the total thickness (which varies from 6 to 8 in.) in one course, it has been the general practice to spread a base course of approximately one-half the total thickness and follow with a second layer of the same size material, as it has been found easier to operate trucks in this way than to plow through 6 or 8 in. of loose gravel.

Two-Course Construction Gives Most Satisfactory Surface.—After observing the methods employed in the construction of the various types of crushed rock and gravel surfacing on many Federal-aid jobs in District 1 and the results obtained, Messrs. McKesson and Morris are convinced that the most satisfactory road surface has been secured where the crushed gravel was placed in two courses; the bottom course consisting of material passing a screen with circular openings of not more than 2 in., preferably 1½ in., and retained on a screen having openings of 1 in. or ⅞-in. diameter and the top course consisting of all material passing the smaller screen.

There is some difference of opinion as to the merits of this method of screening into two sizes before laying. Some engineers argue that it is better to use crusher run material in both courses on the theory that in this way the voids in the base are filled better than if the fines are screened out. If it were possible to obtain a uniform mixture and to maintain this uniformity through the various stages of crushing, screening, hauling, and spreading the rock, there would be no doubt that the crusher-run method would be more desirable, but it is not possible to secure the desired uniformity when all output of the plant falls into one bin.

When the material falls from the screen, the fines cling together in a pyramid, while the larger pebbles and fragments roll down and outward to the sides of the bin. The result is that some loads hauled to the road contain practically all fines, while others consist almost entirely of the larger size stone; so that the theoretically uniform mixture actually consists of a patch of coarse and a patch of fine, with the fines on the bottom and the coarse material on top quite as frequently as otherwise, which is exactly the reverse of what it should be.

Even if every load were uniformly graded and mixed when deposited on the road, which they never are, the process of spreading and dragging necessary to secure a true and uniform surface would tend to work the fine material to the bottom, leaving the coarser particles on top, thus again producing a condition exactly opposed to the ideal, which is more nearly obtained by first laying the heavy rock on the bottom and spreading a top course of fine material.

Importance of Dragging During Construction.—The great importance of constantly dragging and maintaining the surface of the roadway during construction is frequently overlooked. Surfacing is usually begun at the source of supply, so that hauling and trucking of material will be carried on over the newly placed stone until the job is completed. With proper dragging a smooth, uniform surface can be obtained by the time the project is completed, but without dragging the road becomes badly rutted and a rough, unsatisfactory job results. In dragging it has been found advisable to use a light drag in the early stages, gradually filling the ruts as they are formed. If a heavy drag is used which entirely fills the ruts, the trucks are obliged to plow new ruts, and a constant repetition of this operation results principally in an excessive cost for hauling and leaves a poorly compacted surface. With light drags gradually filling the ruts, the ruts are built up and soon traffic can be distributed over the surface

On one Oregon project it was necessary to truck material over the new surfacing up to a distance of 11 miles from the pit. Without proper dragging or water this job made a very poor showing for several months. Two water tanks were then provided, the gravel was kept damp and dragged with light drags, and the job carried to a most satisfactory completion. The cost for watering in this case was about $250 per mile, but upon completion a smooth and well compacted surface was turned over to the public in spite of the heavy trucking during construction. A blade or road planer is necessary to finish such a surface after it has begun to compact under the light drags.

On one project heavy wagon tires dragged over the ruts behind the trucks assisted in filling and compacting the material and in eliminating the ruts.

The advisability of continuing the practice of laying screened or pit-run gravel surfacing without sprinkling and continuous dragging is seriously questioned, except in the rare instances where water can not be obtained. It is true that in nearly every case a fairly good road surface has been secured after properly maintaining it through a winter, with the usual amount of moisture from rain and melting snow; but it is very seldom that such a surface becomes really satisfactory until it has been thoroughly wet down, either by natural means or by the use of sprinklers in the course of construction.

Where water is available the cost per mile for sprinkling and dragging is usually very small as compared with the satisfaction of having a firm, smooth surface as soon as the road is completed. The inconvenience of a loose, rutty surface for the first season, as is so often the case where water and drag are not used, may thus be avoided. The reduced cost of maintenance for the first year where a road is properly compacted during construction will probably offset the cost of water used.

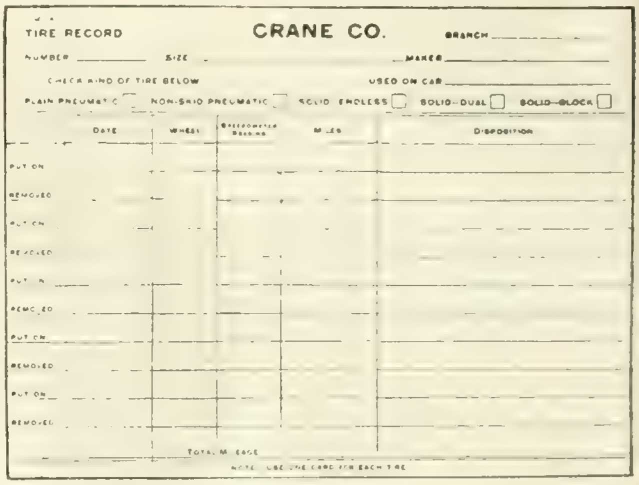
Highways in China.—In ancient China well-constructed courier roads used to radiate from the metropolis to the provincial capitals and from these to other cities of the country. There were more than 60,000 miles of such roads, but nowadays few of them are good for traveling. This, according to the Chinese Government Bureau of Economic Information, is partly the result of age-long neglect of repairing and partly the result of late disuse, since the modern postal and telegraph services no longer employ the old courier roads. A few new roads have indeed been constructed by the municipalities of Peking, Tientsin, Shanghai, Hankow, and other cities, but the government at large has not had the time nor money to build a respectable system of highways for the whole country. Some time ago the Ministry of Interior promulgated a set of regulations for the construction of highways, which fixed the breadth of those to be built by the central government at 50 ft., those by the provincial authorities 30 ft., and those by the district authorities 24 ft. As regards the width of those built by the village authorities, the standard was to be adopted according to the needs of the local community. The program suggested by the ministry is an ambitious one. Although it is not easy to carry it out completely, a good beginning, for example, will have been made if the old courier roads are reconstructed so that there will be 10,000 miles of modern roads radiating from the National Capital and another 50,000 miles radiating from the provincial capitals. The old courier roads make good foundations, and the expense of repairing them will certainly not be so great as that of constructing highways on entirely new roadbeds.

Keeping Records of Motor Truck Tires

How the Crane Co. has reduced the tire expense for its motor trucks is told by W. P. Snidtker, garage superintendent of the company, in 100% Magazine. We quote from his article as follows:

In 1913 we began to give this problem systematic attention and study. Today we can give the exact history of every tire we have bought in the last seven years. This record has taught us a lot about tires that can't be found in books and advertisements. Our basic data are obtained from nothing more complicated than a card which shows the speedometer reading when a tire is put on and the reading when the tire is removed—a tire mileage record.

Our garage serves 62 machines approximately half of which are motor trucks. We have used almost every make and size of tire known. We have learned that every make of tire varies in quality almost from year to year. A tire that gives us excellent life this year may prove a disappointment next year. But our records provide us with information which forms a pretty reliable basis for purchasing. It enables us to buy on demonstrated rather than promised performance.



TIRE RECORD | CRANE CO. | BRANCH ____________

NUMBER ________ SIZE ________ MAKER ____________

CHECK KIND OF TIRE BELOW | USED ON CAR ____________

PLAIN PNEUMATIC ☐ NON-SKID PNEUMATIC ☐ SOLID ENDLESS ☐ SOLID—DUAL ☐ SOLID—BLOCK ☐

	DATE	WHEEL	SPEEDOMETER READING	MILES	DISPOSITION
PUT ON					
REMOVED					
PUT ON					
REMOVED					
PUT ON					
REMOVED					
PUT ON					
REMOVED					
PUT ON					
REMOVED					
		TOTAL MILEAGE			

NOTE—USE ONE CARD FOR EACH TIRE

Card for Tire Record.

Another thing we have found. Accurate tire records make tire guarantees mean something. Tire dealers know that we keep the history of each tire and that our figures can be relied upon. When we go to them for an adjustment and show them a black and white record of our complaint, they invariably do the right thing. In the matter of furnishing trustworthy evidence in cases of adjustment alone, the tire records have saved us thousands of dollars. It makes all the difference in the world whether a man thinks his tire went only a thousand miles when it had to be junked, or whether he knows that to be a fact and has evidence to prove it.

By recording the final disposition that is made of each tire, we have saved in a third way. The "lost, strayed or stolen" expense which formerly we had to bear is now practically wiped out. Tires don't just roll away any longer. They serve their time and then are given a decent burial in a well-known junk pile, and their obituary notice stands in its proper place on the report card.

Tires are one of the greatest problems, if not one of the greatest weaknesses of the motor vehicle at its present stage of development. The perfect tire has yet to be made. Even the tire manufacturers will admit that. But experience proves that there are certain tires and certain combinations of tires that will give better results than others. And who can tell what these combinations are? Surely the manufacturer cannot. Every operator must discover them for himself, and he can do so only if he takes the pains and the interest to record as faithfully as possible the performance of every tire he buys. It requires work. It requires the co-operation of the drivers, but it requires nothing that is impossible or impracticable.

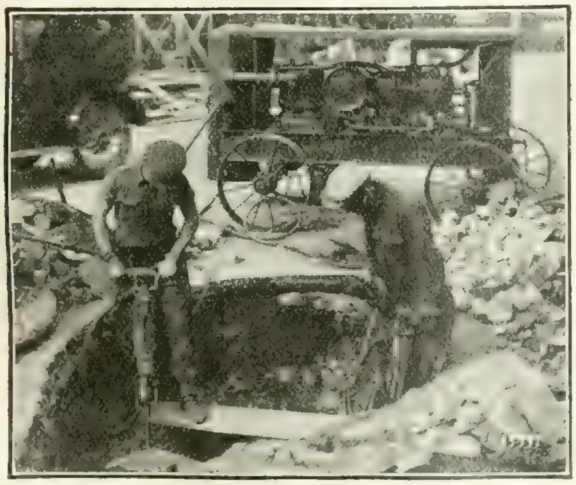
Know what your tires are doing and you will be richer in money and satisfaction.

Removing Pavement by Compressed Air Operated Machines

The use of compressed air operated machines for making pavement cuts is a comparatively recent development. This method is, however, now being used to a considerable extent by electric railways, gas and electric companies and contractors in connection with track work, laying electric cables and service lines, gas mains, street repairing, etc. A new machine, specially designed for work of this kind, has just been placed on the market by the Ingersoll-Rand Co., New York. In this machine the "paving breakers" are very similar in construction to the most modern non-rotating type of hand hammer rock drill. They are extremely simple and rugged, and are all-steel machines, principally dropped forgings, so that they will stand the most severe usage encountered in their work. They are "one-man" machines.

"Paving Breakers" Have Cut Through Asphalt Surface and Concrete Base and Loosened the Subsoil.

Two "paving breakers" are operated by compressed air furnished from one small portable gasoline or electric driven compressor. The portable outfit consists not only of the compressor, but also of the prime mover, which is either a gasoline or an electric motor. A cooling system consisting of radiator, fan, and circulating water pump, and receiver tank, all of which are mounted on substantial steel frame, which in turn is mounted on broad-tread steel wheels, so that the entire outfit may be quickly and easily transported from place to place.


Breaking Concrete for Enlarging Manhole.

Following is a comparison of the machine method versus the hand method for the tearing up of an asphalt pavement and the concrete base for the laying of electric cable duct:

A very good crew of eight men using hand methods will cut about 80 lin. ft. of 18 in. to 24 in. width asphalt and concrete in an 8-hour day. The asphalt averages 3 in. to 6 in. in thickness and the concrete about 6 in. That means 10 ft. per man per day, or 50 ct. per linear foot at a $5.00 wage. Three men with a compressor and two "paving breakers" cut an average of 300 lin. ft. per day. This costs about 16 ct. per linear foot when wages, operating cost, interest, depreciation, etc., are all taken into consideration. That means a saving of two-thirds in cost—and the work is done in about one-quarter of the time. The above figures were furnished by a large Eastern public service company which uses four of the above mentioned outfits.

One of the uses the Los Angeles Railway Corporation has for the "paving breakers" is the cutting of openings on either side of the rail through 6 in. of concrete, having a covering of 2 in. of asphalt. These openings are about 23 in long and extend 17 in. on each side of the rail. Under the old hand method four men with a gad and hammers would not be able to do more than three of these openings a day. Two men with one "paving breaker" cut 22 of these openings in nine hours; that means that one man using mechanical methods replaces 15 men using hand methods, and these men are paid $4.35 each. This work is being done on a track, which is being discontinued. The openings are made in order to give gripping place under the rail for hydraulic jacks by means of which the rail is pulled out.

Application of "Paving Breakers" in Street Railway Work.

As an example of how the work is done, let us take the eastern public service company's job mentioned above. The other types of work are so similar that this will suffice to cover all.

Cutting Trench for Laying Pipes and Electric Cable Ducts.

This company has four 6 in. by 6 in. Ingersoll-Rand Type 14 portable gasoline-driven compressor outfits. Each compressor operates two "paving breakers" working continuously. The crew consists of three men (compressor man and two drill runners). The compressor man is in charge of the crew and relieves the drill man from time to time. These outfits are used for tearing up the asphalt pavement and the concrete base for the purpose of laying cable ducts. They are also used for breaking out masonry for the enlarging of manholes.

In laying cable and service line ducts, stretches of pavement 18 in. to 24 in. wide and varying from 25 ft. to 300 ft. long (and in rarer cases even longer) must be removed. The duct is laid about 3 ft. below the street surface. This means the removal of a 3 in. to 6 in. thickness of asphalt (the asphalt is exceptionally thick), a 6 in. to 8 in. thickness of very dense concrete, and, finally, about 2 ft. of dirt.

A chisel bit is driven through the entire thickness of the asphalt at intervals of about 3 in. to 4 in. along two lines 18 in. to 24 in. apart. This is termed "marking" the asphalt. This "marking" has really the same effect as two parallel grooves. The ends also are "marked." Then the chisel is driven nearly vertically through the full thickness of the asphalt about 12 in. from one end of the job. This breaks a piece about 12 in. by 18 in. of the asphalt off from the main body. Sometimes one cut is necessary to remove a piece this size—sometimes as many as four cuts. It takes only a few seconds to make these cuts. As the asphalt is broken, it is removed by hand by the relief machine operator.

For the concrete base, which averages about 6 in. in thickness, a moil point steel is substituted for the chisel edge steel in the "paving breaker." The moil point steel is driven through the base. First it is driven in about the middle of the trench—that is, 9 in. from either side. This spalls off an irregular "V" shape piece; then two more cuts are made, one 3 in. from each side, which removes the remainder of the concrete along that line. The average is about 3 in. long for three cuts.

After the concrete has been removed, the dirt beneath it is loosened up by driving the moil point steel into it for its entire length. The dirt is then shoveled out by hand until the trench is about 3 ft. deep. Then fiber cable ducts are laid end to end and are completely bedded in concrete. Finally the trench is covered and repaved. Manholes of various sizes and shapes are made at different points and the cable is run through the ducts from one manhole to the other.

Special Tank on Pipe Line Gives Uniform Water Pressure at Concrete Mixer.—An interesting feature of the construction last year of a concrete pavement between Norwalk and Darien, Conn., on the Boston Post Road, was the means used for securing a uniform water pressure at the mixer. Water, taken from a brook fed by springs, was pumped to the job through a 2-in. pipe line. The pump was a double-acting two-cylinder steam rig, with an 8-in. steam cylinder, a 3½-in. water cylinder and a 10-in. stroke. Steam was supplied by a 20 HP. portable boiler. From the pump, water was forced into a steel tank set 3 ft. above the ground. This tank served as a large air chamber, absorbing fluctuations in pressure. It was made specially for this purpose, and was 2½ ft. in diameter by 8 ft. long. Water was admitted on the lower side of the tank, and also was drawn off from below. A relief valve in the discharge line was set to open at any desired pressure between 70 and 100 lb., depending upon the distance pumped. Usually when the pipe line was not more than a mile in length the valve was set at 95 lb. and the working pressure was maintained as nearly as possible at 70 lb., which meant that the tank was about five-sixths full of water and one-sixth full of air. This equipment furnished sufficient water for a 3-sack mixer.

Annual Conference on Street Cleaning.—The International Association of Street Cleaning Officials will hold its annual conference on Aug. 10, 11 and 12 at Chicago. Headquarters will be at the Hotel La Salle. This association was organized last October at a conference called by W. J. Galligan, Assistant Superintendent of Streets of Chicago, and attended by 44 street cleaning officials from 28 cities of the United States and Canada. Active membership in this association is limited to superintendents of street cleaning departments in municipalities and towns of the United States and Canada, and "other persons having charge of or connected with municipal street cleaning departments." Membership of active members is continuous, when once elected, whether they continue in employ of their various municipalities or not. Associate members are "manufacturers of and dealers in appliances relating to the interests kindred to the association." The officials of the association are: President, W. J. Galligan, Bureau of Streets, Chicago, Ill.; Vice President, Theo. Eichhorn, Supt. Dept. of Streets and Public Improvements, Erie, Pa.; Treasurer, Robt. W. Waddell, City Engineer, Kansas City, Mo.; Secretary, A. M. Anderson, 1340, 37 W. Van Buren St., Chicago, Ill.

Importance of Drainage in Road Construction*

By F. H. ENO,

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The usual formula adopted in a road drainage discussion is that road drainage like "all Gual is divided into three parts" or divisions—cross surface, longitudinal or side surface, and subdrainage. Under normal topographical and soil conditions such provisions would undoubtedly secure the desired results. Unhappily for the road engineer, nature is never normal as he encounters her, but she is invariably presenting to him a new variety of conditions.

Under present day road construction practice there is seldom a paved road that does not provide perfect cross drainage, at least from the center of the road to the edge of the paved way. Beyond that point perfection in drainage is difficult of attainment.

Unprotected Earth Shoulders and Cross Drainage.—Following the usual specifications, the road builder finishes his road, smoothly grades the shoulders and berms, cleans and shapes the ditches, and leaves his completed roadway in good order. While in this condition water will run over the surface to the ditch and down the ditches to the outlets with the least possible resistance. Occasionally the plans call for rolled stone or gravel shoulders 2 or 3 ft. wide on either side of the pavement, to permit passing vehicles to leave the pavement and gain it again after passing. Probably 75 per cent of the mileage of paved roads does not have this provision. From the road to the ditch nothing but the original soil intervenes between the unwilling trespasser and the unknown depths.

Two loads of hay cannot easily pass on a 16-ft. pavement. The speeding automobile when meeting a heavy truck must invariably leave the pavement on a 14-ft. roadway, usually upon a 16-ft. pavement and many times even when passing on an 18-ft. paved way. Truck drivers, knowing that the weight of their truck commands respect, are not very respectful themselves of the rights of others when it comes to permitting them to pass.

Picture the aforesaid newly finished road, spick and span, a delight to the eye of the engineer. Two weeks have passed. The road has been inspected by the division engineer and approved, with high praise for its excellent appearance. A three or four days' rain has wept itself out on the shoulders of the road. Two heavy trucks, or two great loads of hay meet on the road, turn out to pass and each runs a wheel out onto the rain soaked shoulders. Two ruts are formed and transverse drainage is ruined. Water stands in these ruts for days, penetrating deeper and wider, until the subgrade is thoroughly softened and almost useless as a support for the road and its traffic.

Ordinary maintenance will not save this trouble. The ruts are filled, and a half hour later the same thing happens again. With daily maintenance—an unheard of thing in America—it is probable that the rut will be there 23 out of 24 hours in the day. Which is the most economical, therefore, filling the ruts each day, repairing or rebuilding the road frequently, or building extension shoulders upon the road at the beginning?

Necessity of Proper Maintenance of Shoulder and Ditch.—Another interference with perfect cross drainage is the gradual elevation of the outer shoulder, due to the grass and weeds growing up and being filled with dust and debris thrown and blown from the traveled way. Frequent scraping with the road grader and the complete removal of the vegetable matter and accumulated dust is the remedy. But how often is this done? Not until after the retained water has penetrated the shoulder and the damage has been done. Possibly a thorough treatment of the entire shoulder and ditch with oil might serve two purposes, waterproof the surfaces and prevent the growth of vegetation. It is true that in many places the unsightliness of this method would be seriously objectionable.

The appearance of a smoothly kept oil shoulder and ditch would be far more pleasing than the unkept tangle of weeds usually found in the roadside ditch. More important than appearance is the life and value of the road.

The lack of proper maintenance practically annuls the usefulness of the ditch. In the long run it would be much more economical to construct ample subdrainage, provide frequent inlets, and grade the roadside ditch into a smooth depression over which a mowing machine could be run.

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*Paper Presented at the 18th annual convention of the American Road Builders' Association.

In Ohio the greater portion of the money expended upon maintenance has been upon the shoulders and ditches of the highways, rather than upon the pavement. With the usual form of ditch the grass and weed cutting along the road must be largely or entirely hand work. Undoubtedly there are places along many roads where a deep ditch is necessary, but wherever light soils are encountered, or the topography will permit, the ditch should become a slight depression gathering the water to inlets into the drainage system below.

The Requirements of the Subgrade.—In order to fully appreciate the importance of drainage in road construction, it may be well to briefly state the requirements of the subgrade. The subgrade must be dry and stable. It must support the road and its traffic load without yielding. If yielding takes place with any monolithic type of road, flexure occurs and in a very short time definite breaks result. In the case of bituminous and other flexible forms, the continuous pounding of the subgrade in the presence of water soon churns the soil and water into a mush which has no supporting power and the road is quickly cut to pieces.

How much deflection of the road, or deformation of the subgrade, can take place without damaging the road surface? Practically none with the monolithic type of road and but the most infinitesimal fraction of an inch with macadam and bituminous bound roads. A perfectly stable and dry, well compacted soil is necessary, therefore, to support roads subjected to heavy traffic. Once having yielded to the load, even 1/16 in., each impact thereafter increases the deformation going on. If water is present the deformation is multiplied rapidly.

Many roadbeds are cut into impervious clay soils; for this reason the subgrade should be given a slight crown to carry any seeping water toward the outside drainage. Provisions should be made so that this water can readily reach the subdrains. The fact that the subgrade is usually trench construction emphasizes the need of the above provisions.

Rolling of Clay Subgrades and Increased Capillarity.—Engineers recognize the necessity of securing a well compacted subgrade. They do not always agree as to the best method of securing it. The question of treating all soils alike needs careful consideration. Undoubtedly, porous, well drained soils can be thoroughly rolled to advantage. Where rolling may be questioned is upon dense clay subgrades. It has been the custom in the past to write but one specification for rolling the subgrade, no matter what character of soil might be encountered. There are a great many varieties of soil in the country. Many times several of these will be grouped in a very limited area. This is especially true in hilly and rolling sections. In Ohio it is not unusual to find three or four kinds of soil exposed in 1,000 ft. of subgrade. The road builder should give careful consideration to this condition if he is to economically accomplish the result he plans to secure.

The farmer has known for years that by rolling the ground in dry weather he can help raise sufficient moisture from beneath to germinate his seed. Prof. F. H. King, of the University of Wisconsin, in the 7th annual report of the Agricultural Experiment Station, 1890, states: "Rolling soil increases its power for drawing water to the surface from below, this influence extending to 3 to 4 ft. in depth." This suggests that possibly there are soils and weather conditions where and when rolling the subgrade should be reduced or eliminated entirely. It suggests the need for a thorough study of capillarity in soils and the effect capillarity may have upon the stability of road subgrades.

Road Builders Should Study Capillarity.—Capillarity has been studied by the agriculturist and the physicist, but so far as the writer knows no study has been given the subject by the road engineer. Prof. Milton Whitney, Chief of the Bureau of Soils, U. S. Department of Agriculture, says regarding the circulation of water in soils (see Maryland Agricultural Report for 1891): "Two forces move water in soils, gravity and the surface tension of the water." He also states that the rate of movement will depend upon: (1) How much space there is in the soil; (2) How this space is divided up; (3) The arrangement of the grains of sand and clay.

He further states that manure, fertilizers, lime and other chemicals change the surface tension of water; affect the arrangement of soil grains, causing flocculation or the drawing together of the extremely fine soil grains, thus changing the texture of the soil and appreciably affecting capillary movement. Prof. Whitney states that the grains in 1 cu. ft. of soil have not less than 50,000 sq. ft. of surface; that in clay soils considerably more than half the volume is open space. He estimated from analyses made of certain Maryland soils that a gram of what is termed Pine Barrens soil contained 1,692,000,000 grains, while a better class of soil known as River Terrace soil—a good wheat land—contained 11,684,000,000 grains. In this latter case he estimated the particles in 1 cu. ft. of soil would have 106,000 sq. ft. of surface, or about 2.3 acres area. This is just a hint of the infinitesimal size of the clay grains and the smallness of the channels that must exist between them. It is in these small channels that the skin tension of water gains its power to draw water for long distances. It has been stated that with some fine grained soils water can be drawn 8 ft. by capillarity. As the soil becomes coarser grained, capillarity decreases until in gravels it practically loses its power.

Prof. King explains an experiment upon horizontal capillarity where he secured a rate of flow of 2⅜ lb. of water per day per square foot of surface. From the brief review of the work done by the investigators of the Agricultural Department, it is quite evident that it will be very important for road builders and those engaged in research work to make exhaustive studies of capillarity in all its varying phases in order to be able to treat subdrainage in an intelligent manner. It is evident that tile drains placed 2 or 3 ft. beneath the side ditches will have little effect upon the amount of capillary water reaching the subgrade of the road, if the soil is fine grained and rests upon a water bearing stratum 4 or 5 ft. below. This suggests the question: Which are more desirable, tile drains beneath the center of the road or tile drains beneath the side ditches?

Action of Soils in Presence of Water.—What is known as the slaking value of clay will give a hint as to how clay will act while absorbing water. Some clays absorb water rapidly, falling to pieces in a minute or less; others take hours; while an occasional clay will stand sharp-edged in water for weeks, apparently unaffected. Some clays disintegrate into slimy slurries; others into powdery appearing masses; some into chunks, and still others into flakes. While making the slaking tests it was noted that a variation in the water content of the clay cylinder at the time it was plunged into the water bath, greatly affected the rate of slaking. Evidently the condition of the soil at the time of a long continued rain storm, or of a sub-stratum of clay at the time of the spring thaw, may variously affect the final result as to whether great harm or small harm is done to a paved road.

Different soils act differently in the presence of water. All of them, with the exception of sand, are made less stable when partially or totally saturated with water. The stability of some soils increases with the water content up to a certain degree of saturation and thereafter rapidly decreases as the degree of saturation continues to increase. Soils vary in their capacity for saturation.

Tests now being carried on in the road laboratory of the Ohio State University Experiment Station show some remarkable differences in this respect. One yellow clay that absorbs water readily will hold but 28 per cent of its weight of water, while another yellow clay which absorbs slowly holds 59 per cent. A grayish clay soil holds 57 per cent, while two black muck soils hold respectively 38 per cent and 170 per cent of water.

The amount of water a clay soil will absorb and the way it disintegrates in its presence, when thoroughly studied, is going to explain many unsuccessful attempts to secure permanent roads. Here again is a suggestion that some water-proofing method of treating the soil may be better than any form of under drainage.

Road No. 12 in northern Ohio is a splendid illustration of some of these peculiar actions of soil and water when brought into contact. It was built by a very competent engineer, who spared no pains in trying to produce a perfect road. The road has a 2-in. asphaltic bound surface upon a 7-in. concrete base. The side ditches are brick paved and located 5 ft. from the edge of the road. Tile drains are laid 2 or 3 ft. beneath the ditches on both sides of the road.

Within three years spots along this road were badly broken, while long stretches were as good as new. The breaks occurred at the brows of hills in cuts. Invariably a dense clay stratum outcropped in the subgrade at the point of failure. At these points the ditches and the drain tile had heavy grades and shed water readily—apparently the very best of drainage conditions—and yet the road failed.

It is not probable that the broken spots were due to excessively heavy traffic, solely, for the same traffic which destroyed the pavement upon these clay outcrops should have destroyed it at other points if the bearing powers of the soils were equal. These clays, when reasonably dry, practically have as high a bearing power as any other soil, but when saturated they have little. Evidently those clay outcrops became saturated and while thus water filled were so reduced in bearing power that the failures occurred. According to what was then considered the best engineering practice, those subgrades should have remained dry, for roof drainage, ditch drainage and tile underdrains were perfect. What occurred? Evidently one of these things happened:

Water may have seeped into the subgrade from ruts along the roadside. (No such ruts were in evidence.)

Water may have percolated through the porous top soil on the hill top, penetrated to the impervious stratum, passing several feet below the tile drains, and, following the impervious clay between the lines of tile, reached the subgrade at the outcrop.

The impervious clay stratum may have rested upon a water bearing soil and by capillarity raised sufficient water to do the damage.

Natural Soil Drainage.—How does Nature drain soils? Is it possible for engineers to utilize Nature's methods to advantage? If an intelligent answer could be found to these questions the road engineer might be greatly helped. D. S. Humphrey of Cleveland, a member of the State Highway Advisory Board of Ohio, claims very emphatically, that most of the highway engineers, in their present practice, are making a serious mistake in cutting through the top soil for their subgrades. He says that if instead of quibbling about grades they would build their road foundation on top of the top soil, largely disregarding the grades, they would get very much better support for their roads and at the same time secure better drainage facilities. He believes that the more organic matter the top soil contains the better subgrades it will make. That surface soil is almost invariably more porous than subsoil no one who has examined soils will deny.

If the top soil is analyzed with reference to its drainage facilities, note: (1) That roots of trees and vegetation have penetrated deeply into it and with the death and decay of these roots, it has been left full of drainage channels; (2) that worms, insects and animals have burrowed through it; (3) that frost has raised it and expanded the pore spaces in it; (4) that percolating waters have leached away many salts, until a well developed and intricate drainage system has been naturally provided.

It is true that outlets must be found for these minute channels, but usually the natural slope provides them. One channel always remains open and that is evaporation. Evaporation is vastly more effective on the surface of the ground than it is in a clay cut. One point that should be stressed in Mr. Humphrey's argument for placing roads on top of the soil is the fact that greater opportunity for leading surface water away through culverts is provided. It also permits much shallower ditches and more fall to the outlets.

A survey of hundreds of road failures in cuts has shown that the top stratum of soil was the most porous and that the porosity decreased as the depth from the surface increased. Hence the water which was accepted more or less freely at the surface was gradually retarded in its flow deeper down permitting saturation to occur in the denser soils, while the soils near the surface were not so completely saturated. This at least argues for less trouble with mushy soils the nearer the roadbed lies to the surface of the ground.

Longitudinal Center Cracks a Form of Road Failure.—In the survey of road failures in Ohio one form of failure has been very frequent and baffling, namely, longitudinal center cracks. One cannot travel over brick or concrete roads anywhere in that state without seeing mile after mile of longitudinal center cracks. Undoubtedly water, frost and traffic are the three responsible agents, with water at the bottom of all of it, but how to prevent the trouble has not yet been solved. The possible combinations of these three criminals are numerous:

The road, having been built upon a solid subgrade, may have had water penetrate beneath its edges from ruts alongside. This softened the soil along the edges of the road so that heavy traffic upon the road broke it over a hard, unyielding center ridge.

Under the above condition, a quick sharp cold wave may have frozen the earth along the edges of the road before the frost could penetrate the pavement sufficiently to freeze beneath the center of the road. The result would be to raise the whole road slab, leaving it supported at the outside edges only. Heavy traffic would then break it down in the center.

The whole subgrade may have become saturated and then frozen solid. The spring thaws then may have thawed out the soil more rapidly on the shoulders and edges of the road than it could through the pavement and the road has been broken down over a solidly frozen ridge beneath its center line.

The whole subgrade may have become saturated and then frozen solid. A warm wave then thawed everything down to about 8 in. or more below the subgrade. A sudden cold wave then froze the outside soil down to the main bed of the frozen soil once more, leaving a mass of water sealed beneath the center of the road. Continued cold finally froze the inclosed water and in its expansion the center of the road was raised and cracked.

The road was laid upon a dense, dry clay subgrade which had been well rolled. The rolling or rise in the ground water caused the subgrade soil to fill by capillarity. Clay swells when it absorbs water and the center of the road was raised and a crack resulted. The same capillarity acts across the whole subgrade width, but evaporation reduces the water content and the consequent swelling at the side of the road.

Further cases might be given, but these serve to indicate the great need for perfect drainage to such a depth that neither vertical nor horizontal capillarity may act. The conditions just enumerated again suggest that not only must drainage be deep enough to prevent the ground water rising to within capillary striking distance of the subgrade, but that probably some form of water-proofing may also be necessary to prevent water from the ditches and ruts on the shoulders being conveyed to the subgrade.

Illinois Practice of Wetting Subgrade.—The writer is informed that in Illinois the highway department treats the subgrade with water before the foundation of the road is laid. The intention evidently is two-fold, namely, to cause the soil to swell as much as it will before the foundation is laid upon it, and to prevent a dry soil from withdrawing water from the concrete to the detriment of the foundation. That some soils swell and shrink in the presence and absence of water, respectively, is very well known by one who has lived near a clay basin. The adobe lands of the West will show many criss-cross cracks, some of them 3 or 4 in. in width, during the dry season. These are entirely closed soon after the wet season begins.

Prof. King says, in the report previously mentioned, that water added to the top of soil will draw water from below by capillarity. He gives experimental data to show that after rainfalls the water in the soil rises to meet the percolating water. If this is true, then the value of the practice of partially saturating the subgrade before constructing the foundation may be questioned. It will be interesting to hear the experience of the Illinois Department regarding the results obtained.

Experiments on Fine Grained Dense Clay Soils.—There is yet one further angle to drainage that needs discussion and investigation. A few of the clay soils tested in the laboratory at the Ohio State University are so fine grained and dense that water will pass through them only by capillarity. The attraction between the clay and the water appears to be so close that the water will not be transmitted to a more porous medium. A bowl, ½ in. thick, shaped out of these clays, will hold water for hours without showing additional moisture on its outer surface.

In one experiment, two 12-in. vitrified tiles were cemented together, making a 12-in. cylinder 4 ft. in length. This was roughened on its inner surface with neat cement mortar and filled with a given clay soil compacted as nearly as possible to the same degree as it originally was in the field. This cylinder full of soil, having a wire mesh across its lower end, was set vertically over a pan and water, 3 in. in depth, poured into the top bell of the pipe. The water gradually percolated away and more was added to maintain the 3-in. depth. After two or three days the water seemed to have ceased percolation and only evaporation seemed active. At the end of a week no water had dripped from its lower end. A ½-in. metal rod was then run down 2 ft. into the soil at six equi-distant points over its surface—the water all the while being maintained 3 in. deep upon the soil. At the end of the second week, no moisture being observable at the bottom end of pipe, the rod was used again and six other ½-in. holes were sunk a full 2 ft. into the soil. The holes were enlarged by wabbling the rod around. These holes were spaced between those formerly sunk in the soil. For one week more water was maintained upon this soil and then it was allowed to evaporate. About three months afterward the soil was dug out of the pipe and it was found that the water had never penetrated within a foot of the bottom of the pipe.

Based upon such evidence, the question immediately arises: Of what value is tile underdrainage laid in that kind of soil? Do not be deceived. Because this soil does not permit water to flow freely through it do not think that it remains stable and that it retains a high bearing power. One of the worst failures on a road in Vinton County, Ohio, occurred where this kind of clay outcropped in the subgrade. The problem of how to treat road foundations through this kind of clay has yet to be solved.

The writer has suggested for trial in Ohio that where dense clay soils are encountered at subgrade elevation, the roadbed trench be deepened from 4 to 6 in. and that depth of coarse, clean gravel or a uniform sized, clean, broken stone be spread beneath the regular foundation. This porous drainage course should be frequently connected with the side ditches or subdrains in order to free it from the collected water.

Summary.—To summarize the paper:

1. Unprotected earth shoulders are easily rutted during spring thaws and wet seasons. These ruts provide easy access for water to reach the subgrade. Building water-proofed hard shoulders along a pavement serves a double purpose—it protects the subgrade from water and adds to the width of road. It may prove to be cheaper than rebuilt pavements.
2. Dust-filled grass shoulders should be eliminated in order to prevent shoulder seepage into the subgrade.
3. Uncleaned ditches add largely to the expense of road maintenance, are unsightly, and in many cases are the direct causes of complete road destruction. The elimination of the ditch, so far as is possible, and the substitution of subdrainage, it is believed, will tend toward economy.
4. The practice of rolling clay subgrades should be carefully investigated to determine whether rolling increases capillarity and if so whether serious harm is done.
5. The whole question of capillary action of water in subgrade soils needs investigation to determine what treatment is necessary with different soils in order to best and most economically prepare the subgrade for the road.
6. The slaking and saturation actions of soils—in fact the whole range of soil and water reactions—should be investigated in order to formulate specifications which the engineers may use for any soil situation encountered in the subgrade.
7. Advantage should be taken of natural soil drainage by building the road on top of the original soil as far as possible. Minimize the cuts. Multiply culverts. Conduct the water away from the road into natural channels as frequently as possible.
8. The question of how to prevent center longitudinal cracks in monolithic roads, and whether swelling soils have anything to do with these cracks, is propounded for investigation and observation. The presence of water in the soil is at the base of both of these actions.
9. The treatment of non-drainable soils to prevent them from being churned into plastic, unstable masses under the road, is a final problem suggested to the road engineer for solution. The porous drainage course beneath the foundation is offered as one solution.

Weighing Heavy Trucks on State Highways.—Five scales for weighing and recording the loads of suspiciously heavy trucks have been purchased by the California State Highway Commission. This is the beginning of a determined effort to keep overloaded and excessively heavy trucks off the public highway in that state. Early in the 1920 season New Jersey started the weighing of suspiciously heavy trucks.

Where to Use Guard Rails

Conditions under which guard rails can be used on highways to distinct advantage were described by Mr. W. W. Cox, engineer-manager road commissioners of St. Clair county, Michigan, in a paper presented Feb. 22 at the 7th annual conference on highway engineering and highway transport of the University of Michigan. An abstract of his paper follows:

On a road where the hard surface or traveled way is narrow, say 9 ft. wide, and the grade is 20 to 24 ft. wide, where the shoulders or berms are of light sand and soil or where they are of heavy clay, many accidents are sure to result from skidding when vehicles pass. Especially is this the case with fast moving and heavy vehicles. This skidding and ending in upsetting in the ditch you may attribute to the carelessness of the driver, but let me ask: Have you ever driven a speedy automobile or a heavily loaded truck on soft or slippery shoulders? If you have, you will agree that even though average care and judgment are used accidents are sure to come where narrow surfaces and poor shoulders exist. These accidents may be more or less expensive, though not fatal. Fatal accidents usually result when the ditches are deep or when the fills are high. As a general rule, it is considered advisable to use guard rails where the ditches are over 4 ft. deep and where the fills are over 4 ft. high.

On roads where the traveled track or hard surface is 16 ft. wide and the grade is 24 to 30 ft. wide, accidents are not so numerous unless the surface is rough and the traffic is too congested. However, as traffic increases we find that the number of accidents increases proportionately.

On roads where the traveled track or hard surface is wide enough to accommodate traffic, so that vehicles may pass freely and without getting off the surface to do so, the dangers of skidding to the ditch are eliminated. This holds true except when rain, snow or ice literally greases the skids.

Protection Needed at Danger Points.—All roads, by virtue of their traffic conditions and by virtue of the difficulties encountered in their design and construction, do have their danger points and death traps where protection should be provided.

The most common of these is found in flat clay sections where deep drains become imperative for the improvement of the road and the adjacent farm lands. These ditches vary in depth from 3 to 12 ft. and very often follow along the road for miles. In these sections we find the customary township line offsets where existing drain improvements prohibit new locations. Where intersecting roads or right angle turns must remain near these ditches it is necessary and advisable to protect the corners or turns.

In the rolling or hilly sections high fills must be made in order to reduce the grades. These fills, either of sand or clay, are subject to washouts and settlement, thus becoming dangerous when over a few feet high unless they are made exceptionally wide. Even the wide grade is treacherous if it is located on a steep gradient.

Approaches to bridges and culverts should also be protected. More especially is this true when the roadway is narrowed at these structures or when high water is likely to disturb the fills.

Types of Guard Rails.—Guard rails should always be used when there is a question of safety involved, and when used they should be made strong and substantial. They may be constructed of rock in places where proper rock is obtainable to make a strong and pleasing rock wall. Reinforced concrete may be pre-cast and assembled into one firm, strong, pleasing structure. Guard rails which are most common in this section are constructed of timber. The latter should be built of 8-in. cedar posts placed not more than 8 ft. apart. The posts should be set into the ground not less than 3 ft., or deeper in loose soils. They should be placed not at the outer edge of the berm or shoulder, but within it and at least 1 ft. from the beginning of the side of the slope.

The side rails, usually three in number, should be of good clear lumber, not less than 2 in. thick and 8 in. wide. These should be thoroughly spiked and lag screwed to the posts. The lower rails should be on center a distance of 15 in. from the ground. The top rail should be placed on top of the post so as to show up well, to strengthen the structure and to protect the top of the post from decay. The height of the structure should be not less than 3 to 4 ft. The whole should be painted with a good grade of white lead and oil paint.

Highway Construction Progress in Illinois in 1920

By B. H. PIEPMEIER

[illegible] Construction Division, [illegible] Department of Public Works [illegible]

The accompanying charts graphically represent the progress made by weeks during 1919 [illegible] construction of paved roads in Illinois. A casual examination of the two years' work clearly shows the advantage of the early [illegible] contracts. During 1919 approximately [illegible] miles were awarded in April, May, June and July, the peak of road mileage being awarded in May. The progress chart for 1919 shows that the contractors did not reach their peak of miles completed per week until October, some five months later.

It is generally recognized that it takes a contractor 60 days to organize and get ready to lay pavement and from 30 or 50 days to reach his maximum output after he starts.

The 1920 chart shows that the peak mileage constructed for any one week was reached the week ending Oct. 1, 1920. However, a very large weekly mileage was reached in June and was practically maintained for a period of four months, when construction suddenly slumped on account of winter. A good weekly record was made in June on account of a large mileage of work being carried over from 1919. In the spring of 1920 many of the contractors had equipment on their jobs and were ready to start construction as soon as weather conditions permitted and they could organize their forces.

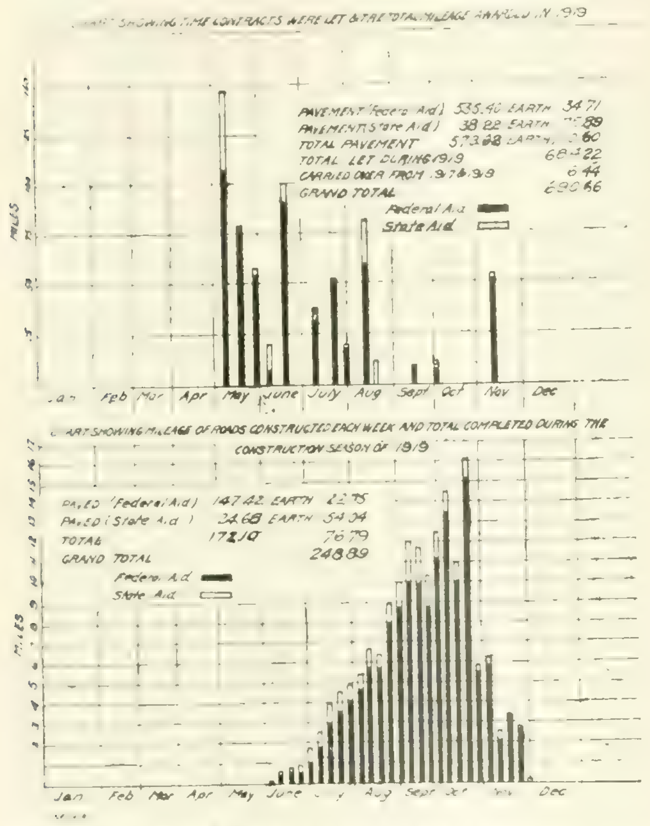


Chart Showing Time Contracts Were Let and Total Miles Awarded in 1919.

The chart indicates a large mileage of earth work awarded during the late summer months of 1920. The peak of grading work was reached week ending Nov. 4, 1920, a comparatively short period after the peak of awards were made. Experience has shown that on grading work a contractor can reach his maximum of yardage moved per day within 30 days after the awarding of his contract, while on pavement construction he must count on at least 90 days.

It is generally recognized that 1920 was a very trying year for contractors. Their output of work was curtailed on account of practically every conceivable difficulty. Labor troubles, transportation difficulties and material shortage were the chief causes of delay, however, regardless of the difficulty, many contractors were successful in the execution of their work.

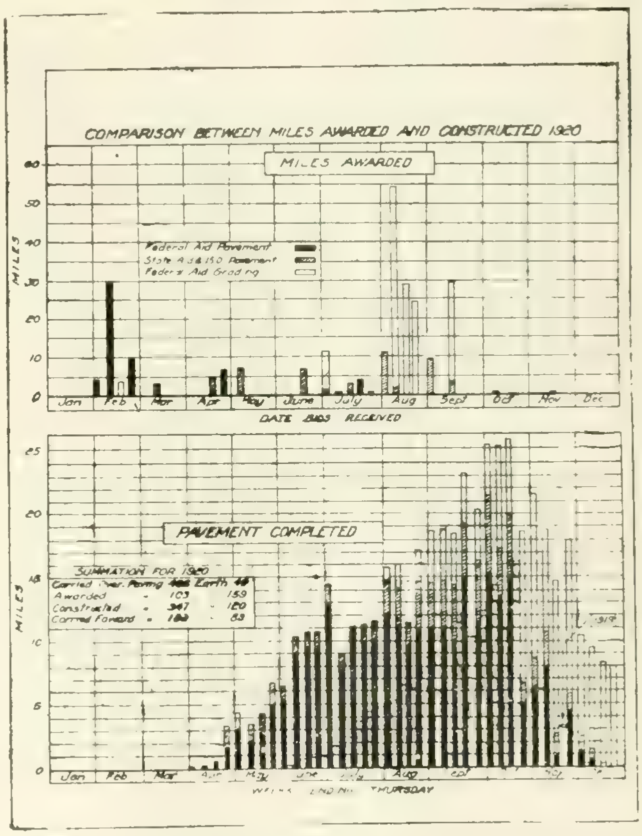
During 1920 there were 133 contractors doing work on state roads. They completed 347 miles of pavement and 120 miles of earth grading. Out of this number 87 contractors carried work over into 1921, having a balance of 192 miles of pavement and 83 miles of grading to complete.

On account of unfavorable conditions that existed throughout the season no exceptional records were made or no one method of handling work proved to be worthy of special mention or recommendation; however, a few brief statistics of the work that was done during 1920 may be of interest to contractors and engineers.

The largest number of days a concrete paver was operated on a single job was 131. The largest number of square yards laid during the season by the use of one mixer was 86,592 sq. yd. or 8.2 miles of 18 ft. pavement. This was done in 107 working days using trucks to deliver materials direct to the paving mixer.

The largest number of square yards laid under the supervision of one contractor was 260,000 sq. yd. or 27.45 miles.

The largest daily output with one mixer was 1,694 sq. yd. or 847 ft. of 18-ft pavement. On this job an 8-bag paver and industrial railroad for transportation of materials were used. The largest week as well as the largest month's record (0.72 miles and 2.44 miles, respectively) were made by a contractor using a 4-bag paver with industrial railroad delivery of materials.



Comparison Between Miles Awarded and Constructed in 1920.

A further analysis of all jobs shows that industrial railroad equipment was used on 44 jobs, the average of which shows 1940 ft. per week and 5,264 ft. per month.

Central mixing plants with truck delivery of mixed concrete were used on 12 jobs, the average of which showed 1,495 ft. per week and 4,272 ft. per month.

Batch boxes on trucks delivering materials direct to the paving mixer, were used on 11 jobs, the average of which showed 1,331 ft. per week and 2,589 ft. per month.

On four jobs material was dumped on subgrade using a belt conveyor to the paving mixers, the average of which showed 1,022 ft. per week and 5,563 ft. per month.

There were 48 jobs where materials were dumped on subgrade and shoveled or wheeled to paving mixture. The average progress on these was 1,462 ft. per week and 3,117 ft. per month.

Methods and Cost of Constructing Bituminous Surfaces on Old Macadam at Denver, Colo.

The city and county of Denver, during the past 10 years, have paved a number of streets with various types of bituminous surfaces on old macadam bases. The different types laid to date are asphaltic concrete, tar concrete, Amiesite, sheet asphalt, and Willite. The first attempt at this construction was made by the city in 1910, when four blocks on Speer Blvd. were paved. Three types of pavement were laid in the following order, each type being used throughout one block: Asphalt concrete, tar concrete, Amiesite, and tar concrete. In 1912 the paving on this street was continued for a distance of eight blocks, using asphalt concrete. In the same year a block on 18th Ave., from Sherman to Grant, was paved with Amiesite. In 1913 the block between Sherman and Lincoln on 18th Ave. was paved with asphalt concrete. In 1916, 1917, and 1918, 35 to 40 blocks were paved with sheet asphalt and asphalt concrete. One block of Willite was laid in 1919. In 1920 a total of 112,920 sq. yd. of asphalt concrete and Willite pavement was laid The following account of the methods employed in this work and the results obtained are taken from an article by Mr. J. W. Johnson, Senior Highway Engineer, U. S. Bureau of Public Roads in the current issue of Public Roads.

All of the streets paved in this manner had previously been improved by grading, curbing, and gutter and surfacing. The surfacing originally placed varied in different parts of the city. Disintegrated granite, slag, and oil macadam were used.

The width of the streets varied from 30 to 40 ft between curbs. The width of the gutter was usually 2 ft. The crown varied from 8 to 12 in. All of the streets had previously been supplied with storm sewers. Intakes to sewers were provided at intervals so that the maximum length of run-off of surface water was about 600 ft.

Owing to the light annual precipitation (an average of about 14 in.), the high crown on pavements, and the short distances that surface water has to travel before entering sewers, there is very little opportunity for the subgrade to become wet so long as the pavement is in good condition. Only a very few places where settlements of the subgrade has occurred are in evidence. Practically all of these defects occur under the earlier pavements.

With the exception of a small amount of Willite, all of the 1920 construction was asphaltic concrete, 1½ in. thick on a 1½-in. binder course. Both Mexican and California asphalt, with a penetration of from 50 to 60, were used. The binder course was mixed in the proportion of 50 lb. of asphaltic cement to 250 lb. of sand and 750 lb. smelter slag (maximum size 1 in.). The surface course was mixed in the proportion of 80 lb. of asphaltic cement to 85 lb. of limestone dust, 300 lb. of slag (maximum size ⅝ in.), and 535 lb. of sand.

The mixing was done at stationary plants and the material was transported to the job in auto trucks. The mixing plants and trucks are owned and operated by the city. All of the work, including the grading and preparation of the subgrade, is done by the city by day labor. No contracts are let for any portion of the work of this character.

Preparation of Subgrade.—The surface of the street selected for paving is scarified by the use of a scarifier attached to a heavy blade machine and pulled by a 10-ton caterpillar tractor. The depth and amount of scarifying depends on the condition of the old macadam and the amount necessary to be removed. As all of the streets paved have either brick or concrete gutters, it becomes necessary to remove 3 in. of old material at the junction of pavement and gutter. From this point the amount of material removed is decreased to the center of the road, where only the amount necessary to bring the road to a uniform crown is taken off.

The material loosened by the scarifier is bladed into windrows, about 6 ft. wide and 3 ft. high, and then loaded into wagons by means of a traveling bucket loader. After the excess material is removed the roadbed is thoroughly rolled until hard and firm. All depressions are then filled with good material and again rolled and brought to a uniform grade and cross section.

Upon this subgrade the asphalt binder course and surface course are laid in accordance with usual practice in laying asphalt pavement

Cost of Pavement.—The number of square yards of pavement of this character laid during the season of 1920 was 112,920. The total cost of this work was $127,768.77, which is at the rate of $1.13 per square yard. This price included the grading necessary to prepare the subgrade.

The average cost of grading amounted to $0.15 per square yard of pavement. In other words, the pavement cost an average of $0.98, and the grading $0.15 per square yard.

The items of cost of the work done in 1920 are as follows:

Item.	Cost per sq. yd
Surface mixture	$0.281
Binder mixture	.210
Fuel	.071
Expense	.010
Tools and sundries	.023
Plant repairs	.030
Depreciation, plant	.013
General salaries	.040
General labor	013
Plant labor	115
Street labor	.088
Hauling	086
Total for surfacing	$0.980
Grading	150
Total	$1.13

The various charges entering into the above items are explained as follows: Surface and binder mixture include the cost of asphalt, limestone dust, sand and slag which are used in them

Fuel covers all coal used at plant and on steam rollers on job and fuel oil in the dryer and electric power for derrick.

Expense includes insurance, taxes, printing, automobile and miscellaneous expenditures.

Tools and sundries include the purchase of tools and miscellaneous plant supplies, water rental, horse feed and shoeing, lubricating oil and grease.

Plant repairs include repairs and replacements to plant and roller parts; also labor in getting plant in shape before starting up in the spring.

Depreciation is 20 per cent of the cost of new equipment purchased.

General salaries include those of the superintendent, bookkeeper at plant, clerk at administrative office, and an inspector.

General labor includes labor in building addition to plant, assembling derrick and any other work not properly chargeable to operation.

Plant labor includes all labor used in operating the plant.

Street labor includes all labor used on the street in laying the binder and top.

Hauling includes the cost of trucks and drivers, and street rollers and operators.

Grading includes all labor in preparing subgrade.

Present Condition of Pavement.—The most noticeable defects in the present condition of these pavements are sunken spots, roughness or waves in the surface, and surface cracks. The sunken places are all on work done in 1910 and 1912. The largest of these have a diameter of from 8 to 10 ft., and are possibly 8 to 12 in. below grade. This condition is caused by settlement of the subgrade, which was on a comparatively new fill of from 4 to 10 or 12 ft. The street on which these sunken places occur was built along the bank of Cheery Creek, parallel to new retaining walls built to confine the water course of the creek. The surfacing was placed on this fill within two years after it was constructed, and evidently prior to the time of complete settlement.

Roughness and waves are in evidence on a number of streets laid during the early period of this construction. Apparently this condition is caused by insufficient care in laying the pavement, or insufficient rolling of the subgrade. This condition does not exist to any extent in work done since 1916.

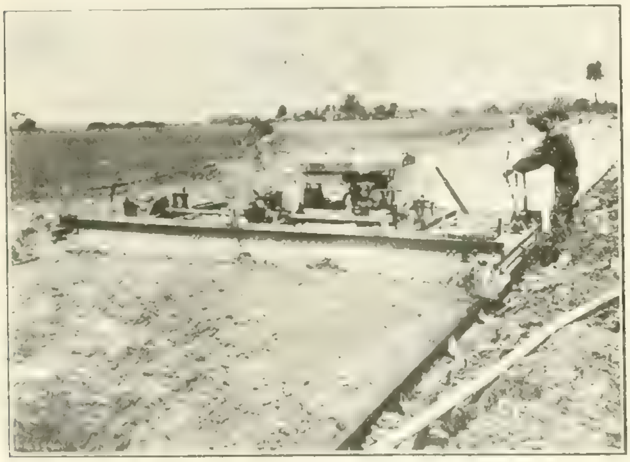
Transverse cracks in the pavement laid in 1916, 1917, and 1918 are in evidence throughout a large portion of the work. These cracks are usually at right angles to the center line of roadway. Sometimes they extend entirely across the pavement from gutter to gutter, and sometimes they extend only a distance of 6 or 8 ft. each side of the center. Apparently they are caused by contraction and do not indicate any serious permanent defect in the wearing qualities. The distance between them varies considerably; ordinarily they are not less than 30 ft. apart.

One block of surfacing laid in 1919 shows the worst cracking of any so far laid. This pavement is so badly cracked that it will undoubtedly have to be replaced in a very short time. In fact it should be replaced this season. This cracking was apparently caused by the pavement being mixed with too small a percentage of asphalt. The resulting mixture was too brittle, and severe cracking was evident after the first cold weather in the fall after the pavement was laid.

One disadvantage in this method of constructing pavements is the high crown which very often obtains. This result is caused from the desire to use all of the old macadam possible in the center of the road, and the necessity of meeting the gutter already in place. As the macadam has usually been given a good crown for drainage, the addition of 3 in. of bituminous pavement will as a rule result in 1 or 2 in. of additional crown. This result would be more undesirable in a wet, cold climate than under the climatic conditions usual in Denver.

New Road Tamper and Finisher

A road tamper and finisher having several new features has been placed in production by the Austin Machinery Corp., Chicago. In this machine, in order to eliminate voids or air pockets caused by the ordinary strike-off, necessitating going over the work four or five times with other mechanical tamping devices, the strike-off is followed by a roughing tamper. This roughing member may be arranged to chop or tamp simply by turning over the channel. To acquire the chopping action the legs of the channel are turned down. When straight tamping is required, the legs are turned up. The smoothing tamper, alternating its blow with the roughing tamper, is arranged to bring the water to the surface, finishing the concrete to such an extent that the follow-up unit, the smoothing belt, could be eliminated were it not for the presence of water on the concrete. The smoothing belt is used to carry the water from the surface of the road to the side of the forms. Primarily the machine consists of two tamping members—one, a roughing tamper, and the other, the smoothing tamper—so arranged as to provide a reciprocating tamping action. The tamping members are made from 6-in. channels, extending the full width of the road, striking a blow over an area of 6 in. The tampers are driven through three eccentrics each, which cause them to strike a sharp, even blow, uniformly distributed throughout the entire width of the tamping member. The alternating action of the tamping bars almost eliminates vibration. The ample power supplied by a four-cylinder gasoline engine enables it to push the strike-board against the rough concrete and tamp up steep grades. The machine is one-man controlled and may be operated from either side of the road, as it has control levers on both sides. All castings are made of cast steel. Structural steel is used throughout in the construction of the main frame. Shafts are made of special alloy steel. Friction clutches are provided for each operation. The machine is made in standard sizes for roads of 12, 14, 16 and 18 ft.

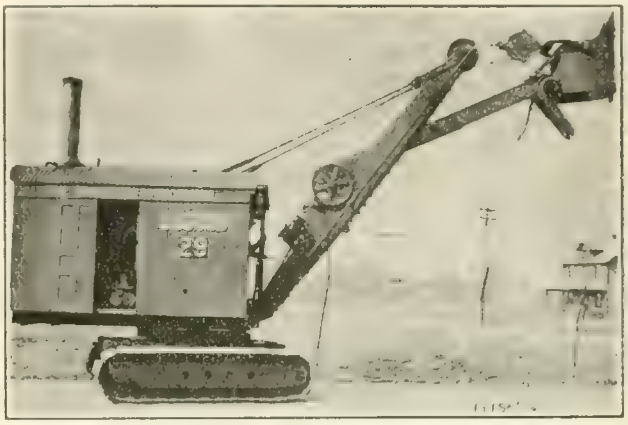


New Austin Tamper Working on Concrete Road Job at Maywood, Ill.; Ready & Callaghan, Contractors.

China to Build Wider Roads.—According to reports from the Permanent International Association of Road Congresses, Hsu Shih Chang, president of the Chinese Republic, has issued an executive order providing that in carrying out the Chinese good roads program, roads hereafter shall be wider. Roads connecting Peking with the capitals of the provinces, hereafter, will be 55 ft. wide and those connecting the capitals of the provinces with the seats of the districts will be at least 33 ft. wide. Roads between the district seats are to [illegible] wide.

1-Yd. Revolving Steam Shovel with Continuous Tread Mounting

The Osgood Co., Marion, O., has recently brought out a continuous tread mounting for the Osgood 29 1-yard revolving steam shovel. This machine is built along the same lines as the Osgood 18, ¾-yd. machine. The tread belts extend but a short distance beyond the ends of the truck frame, which feature permits the machine to be operated from either end and owing to its compactness interferes as little as possible with the operation of the dipper, also allowing the machine to be turned in a much smaller circle than when longer belts are used. The tread belts are so constructed as to enable either side to be adjusted easily and independent of the other side. It is stated the machine will climb a comparatively steep grade and propel with ease over very soft or uneven ground.

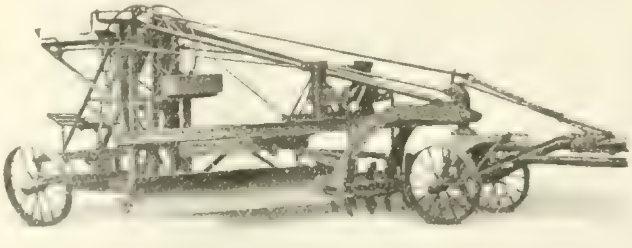


New Osgood 1-Yd. Revolving Steam Shovel on Continuous Tread Mounting.

The truck frame used on the continuous tread machine is a 1-piece open hearth, annealed, steel casting and interchangeable with the traction trucks and like the Osgood 18 the new machine can be easily converted into a clamshell or dragline outfit.

New Scarifier-Grader

A new combination scarifying and grading machine has been brought out by J. D. Adams & Co., Indianapolis, Ind. The machine scarifies and grades at the same time, or the scarifier or blade may be used independently. The scarifier has seven teeth, 3 in. x 1 in. x 20 in. long, and cuts a swath 45 in. wide. The grader blade is 8 ft. long and 18 in. wide with mold board. The scarifier is raised and lowered by two cranks, one on either side of the operating platform, and the depth of cut may be adjusted to a fraction of an inch. The grader blade is fully adjustable and is raised or lowered, either end independently, by two large hand wheels at the operator's platform. The length between front and rear axles of the machine is 15 ft. The front wheel tread is 3½ ft. and rear 5 ft. 9 in. The weight complete is 5,600 lb. The machine has the adjustable leaning-wheel feature of the other Adams graders.

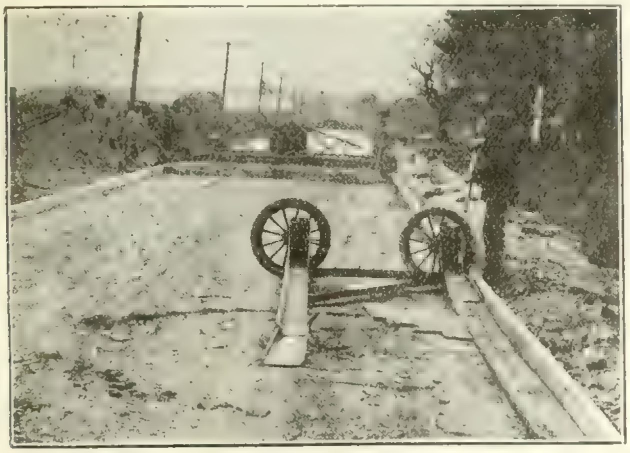


Adams Scarifier-Grader No. 8-A.

State Highway Board of New Jersey to Be Salaried.—Governor Edwards of New Jersey has approved the bill which will give each of the members of the State Highway Commission a salary of $4,000 a year. Heretofore this commission has been non-salaried and formerly it met once a month. The demands of the work incident to the construction of the new state highway system has compelled the present board to hold meetings practically every week.

Portable Turntable for Turning Trucks on Sub-Grade

A light, portable turntable for turning motor trucks on the subgrade that gave excellent service during the construction last season of 7 miles of 18-ft. concrete road at Highland, Ill., is illustrated below. It is stated a truck can be turned with this turntable in 8 seconds. The operating method is simple. When the subgrade is in proper condition, ready for the slab, the trucks turn the turntable by their own power, the right front wheel striking a spring bumper and one rear wheel driving on the ground. After the truck has been turned one man pushes the turntable back to position, ready to receive the next truck. The turntable was invented and patented by Mr. C. J. Hug, of the Hug Lumber and Construction Co., Highland, Ill. This company used it on the Highland job and has now placed it on the market. The turntable is made in two sizes—one for 1-ton Ford trucks, the other for 2½-ton trucks.



Hug Truck Turntable.

Federal Aid Road Types

On March 1 of this year, according to a recently issued statement of T. H. McDonald, Chief U. S. Bureau of Public Roads, 22,030 miles of Federal-aid highway, extending into every State, had been completed or were in process of construction, at a total estimated cost of $361,946,868. The percentage of this total estimated cost which will be incurred for each type, and the mileage of each type, based upon the records of plans approved, are as follows:

	Per cent of total estimated cost.	Mileage.
Type 1, including earth, sand-clay and gravel	32.2	15,300
Type 2, including water bound and bituminous macadam	9.0	1,530
Type 3, including brick, bituminous concrete, Portland cement concrete	48.8	1,890
Miscellaneous	4.0	310
Bridges	6.0	......
	100.0	22,030

Many times the question has been asked the Bureau: What type of road is best? The answer is always the same: There is no one best kind or type of road surface.

A recent statement issued by the officials of the Bureau expresses this thought in the following language:

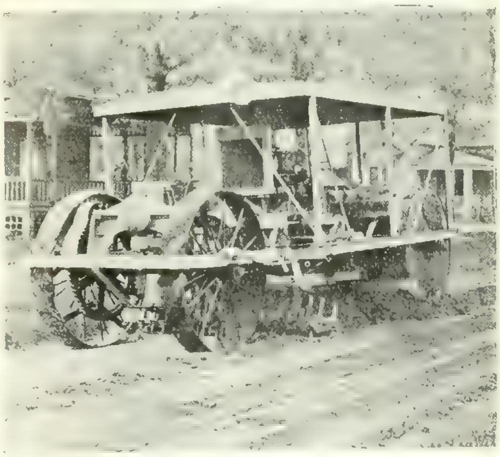
"It is the policy of this Bureau to consider the conditions on each individual Federal aid project, as there are elements such as subgrade, drainage and present and prospective traffic, which vitally affect the determination of the standards of construction to be used."

That is, there must be a careful analysis both of the engineering and economic conditions for each particular case to determine the kinds of materials that can be used successfully, and after these facts are determined then the various types of construction which can be used economically should be brought into competition to secure the best possible results. There have been occasional attempts to write into State laws or the governing conditions of bond issues a requirement as to the type or kind of roads to be constructed. To follow such a course would be most unfortunate. The cost must always be considered in determining the type of road surfaces which are selected, and the allowable cost must be determined by the traffic which is to be borne. Local conditions vary to such an extent that very careful consideration must be given each project before determining the character or type of roads to be built. This principle was recently expressed to a Chamber of Commerce asking for information, in the following language:

"Types of highways should not be specified by law. This is a matter to be decided by the State highway department in which should be lodged full authority both to construct and to maintain. Competition between different types of material should be maintained and selection made to fit traffic requirements in each case. The Bureau does not recommend any one type to exclusion of others."

Combined Scarifier, Grader and Roller Road Machine

A road machine, combining a scarifier, grader and roller, is illustrated below. The machine is driven by a 4-cylinder, 45-H.P. Liberty Continental governed motor. The transmission is fully enclosed, having 2-in. faced cut gears, two speeds forward and one reverse. The low speed forward is 2 miles per hour; the high speed is 4 miles per hour, and the reverse speed 2 miles per hour. The scarifier has 18 teeth, 19 in. in length, reversible end for end, and held in place by a special device without the use of any bolts. The width of cut is 7 ft. 5 in. The grader blade is 10 ft. in length. The mould board is 18 in. wide, including a 6-in. cutting blade. Both the scarifier and grader blade are operated by a mechanical oil pump. The rear rollers are 30 in. wide and 5 ft. in diameter, made of special steel with water-tight compartments for loading with water to secure additional weight. The normal compression of rear rollers is about 240 lb. per square inch. By loading with water this can be increased to from 280 to 300 lb. The total weight of the machine is about 13 tons. Its length is 22 ft., width 8 ft. 3 in., and height 9 ft. The machine is operated by one man. It is made by the American Road Machinery Co., Monroe, Mich.



The Oswald Triple Action Road Machine.

Cost of Feeding Street Department Horses at Cincinnati, O.—During 1920 the Department of Street, Sewer and Catchbasin Cleaning of Cincinnati, O., maintained 236 horses and 39 mules. The average cost of feed, according to the annual report of Fred Maag, Superintendent, was 71.1 ct. per horse per day. The average daily ration was:

	Per horse. Lb.
Hay at $38 per ton	15.6
Oats at 2.8 ct. per lb.	11.7
Nutma at 2.9 ct. per lb.	3.0

Old Roman Road Discovered.—Discovery has been made in England of another old Roman road hitherto unknown. Workmen who were digging manholes on the Alton road where the latter joins the roads to Bentley and Bordon, near Farnham, Surrey, unearthed, 5 ft. below the surface, part of what appears to be on old Roman road that ran from London to Manchester. The road was in an excellent state of preservation, the surface layer being a foot in thickness and composed of flints. In order to penetrate the surface the workmen had to use drills and steel wedges.

An Asphalt Block Press for Use with Asphalt Paving Plant

[illegible] press, so de[illegible] [illegible] installed in an asphalt paving plant without altering any of the latter's existing features, has been brought out by the National Moulding Press Corporation, 262 Fulton St., Brooklyn, N. Y. In addition the aggregate and asphalt for the blocks can be mixed by the same appliances as used for the asphalt paving mixture. The press is constructed as a single unit and can be operated either by an electric motor or by a belt connection with an existing shaft in the plant. The mixture is fed to the hopper of the block machine from the upper floor of the plant, the correct rate of feeding being insured by an automatic indicator. The mixture drops from the hopper into the mould and is compressed by two plungers, one moving upward and the other downward, under a pressure that can be regulated as desired up to 400 tons. After the block is compressed it is raised by the lower plunger to the level of a belt conveyor, which carries it through a trough of water. The blocks when they leave the trough are sufficiently cooled and solid so that they can be stacked for shipment. The press occupies a space 4 by 7 ft. and stands about 8 ft. above the floor. It requires 25 to 30 HP. for operation and has a capacity of approximately 1,000 standard asphalt blocks or tile per hour. The same machine can be used for making blocks of any of three regular commercial thicknesses. The advantages claimed for the machine are: Compactness; economy of maintenance; absolute control of pressure exerted on the blocks; the feeding of the mixture to the mould, and the regulation of the uniformity of the blocks by means of a system of automatic safety devices.

Asphalt Block Press.

Wire Mesh Roads on Sand.—Loose sand, smoothed and leveled and covered with chicken wire netting, firmly pegged down, made roads which gave good service to the British Army in Egypt and Palestine, according to the Reserve Engineer (London). These roads were very satisfactory for foot troops and of some use for motor transport, but were rapidly rendered useless by animal drawn transport. Repairs were easily made. As ruts developed the netting was raised and the rut wiped out.

Illinois Counties Can Bid on State Road Work.—Governor Small of Illinois on May 9 signed the bill giving counties of the state the right to bid on road construction and giving the state the right to buy or condemn cement factories for use by the state. The bill opens the way for counties of the state to become competitors in road building, and the state has the right to take charge of cement plants if it is apparent that the price of cement asked by large companies is exorbitant. Under the road building clause in the bill counties may take contracts for road construction and will be paid for the work out of state funds.

Boulevard Project for Seattle, Wash.—Seattle is considering the provision of a new boulevard which will extend south from a plaza near the railway station. The width will provide two roadways for motor traffic, and a middle section for street cars. The crossings will be overhead or underneath. This is a provision for a direct means of entering the city without adding to the down-town traffic congestion.

Philadelphia to Pave 60 Miles of Streets.—Philadelphia is expecting to pave 60 miles of streets this year. For this work $1,000,000 will be paid out of current revenues, and $5,000,000 obtained from a loan.

2,739 Cities in United States.—There were 2,739 municipalities of 2,500 or more inhabitants in the United States in 1920.

Personals

Maj. L. D. Blauvelt has been appointed state highway engineer of Colorado.

Herbert Livermore has been appointed street commissioner of Johnson City, Tenn.

P. C. Moore, of Butte, Mont., has been appointed chief of the maintenance department of the State Highway Commission.

John F. Galvin, a newspaper man of Richmond, Calif., has been appointed secretary of the California State Highway Commission.

George B. Hughes, formerly district state highway engineer for St. Louis County, Minnesota, with headquarters at Ely, Minn., has been appointed as district engineer, and has a part of Itasca County under his general supervision. Mr. Hughes will have headquarters at Virginia, Minn.

C. O. Markhart and Prof. H. R. Thayer, formerly of the Carnegie Institute of Technology, have formed a company to be known as the Markhart Thayer Engineering Co., to take over the business of Brown, Egermann & Markhart, civil engineers and architects, with offices in the Fulton Bldg., Pittsburgh, Pa.

Chester M. Clark, formerly head of the corporation department of Stone & Webster, Inc., and during the war secretary of the underlying company at Hog Island and assistant to Matthew Brush the president of that corporation, has been elected treasurer of Arthur D. Little, Inc., Cambridge, Mass.

Merton R. Sumner has been appointed chief engineer of Arthur D. Little, Inc., chemists, engineers and managers, Cambridge, Mass. Mr. Sumner was formerly chief engineer for New England of Fred T. Ley & Co., Inc., in charge of about 125 construction projects and more recently was chief engineer of the Fuller Industrial Engineering Corporation, a subsidiary of the George A. Fuller Co.

Major D. Q. McComb, division engineer, West Tennessee division, State Highway Department, has been appointed chief engineer of the Tennessee Highway Department. Major McComb is a mechanical engineer graduate, '00, of Colorado Agricultural College; a civil engineer graduate, '10, of University of Illinois, and a post-graduate in highway engineering of Columbia University. He is an engineer of over 13 years' experience in the employ of the Philippine Bureau of Education; in the Philippine Bureau of Public Works as assistant and district engineer; with the Pittsburgh Testing Laboratory, Birmingham, Ala., as chemist; as highway engineer, U. S. Bureau of Public Roads, and as division engineer, Tennessee Highway Department. During the recent world war he was one of the "first 10,000" to be commissioned in the Officers' Reserve Corps, serving throughout the war as an officer of an engineer regiment (regulars) on fortification duty in the Philippine Islands.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Road Forms.—Heltzel Steel Form & Iron Co., Warren, O. Folder giving information on the Heltzel steel form.

Asphalt Mixing Plants.—Barber Asphalt Paving Co., Philadelphia, Pa. 20 page bulletin illustrating and describing the asphalt mixing plants produced by this company.

Locomotive Cranes.—Orton & Steinbrenner Co., Chicago, Ill. 12 page catalog illustrating and describing the new 7-ton and 12-ton crawling tread and road wheel locomotive cranes of the company.

Concrete.—Koehring Co., Milwaukee, Wis. 207 page book on the manufacture and use of concrete. Contains in concise and readable form a large amount of useful information on concreting operations. A particularly valuable feature of the book for the contractor is the suggestions on the care and operation of construction equipment. The chapters in the book are as follows: Chapter 1, Field Operations in Concrete Construction; Chapter 2, Materials Entering Concrete; Chapter 3, Concrete in Highway Construction; Chapter 4, Miscellaneous Notes for Superintendent and Foreman; Chapter 5, Forms for Concrete Construction; Chapter 6, Use of Reinforcing Steel in Concrete; Chapter 7 Notes on Specifications; Chapter 8, Estimating Cost of Concrete Construction; Chapter 9, Notes on Culvert and Bridge Construction; Chapter 10, Convenient Estimating Tables and Examples of Use; Chapter 11, Foundations and Footings; Chapter 12, Waterproofing of Concrete; Chapter 13, Placing Concrete Under Water; Chapter 14, Notes on S[illegible] Coal and Material Bins and Grain Tanks; Chapter 15, Mechanical Equipment—Its Starting, Care and Operation.

Waterworks and Hydraulics Monthly Issue

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Roads and Streets—1st Wednesday
(a) Roads (c) Street Cleaning
(b) Streets (d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks (c) Irrigation and Drainage
(b) Sewers and Sanitation (d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation (c) Quarries and Pits
(b) Management and Office System (d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings (d) Miscellaneous Structures
(b) Bridges (e) Properties of Materials
(c) Harbor Structures (f) Management and Office System

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Pueblo Suggests

According to reports from Colorado prior to our going to press, a large part of the recent flood damage to life and property was due to dam failures. Public blame for this, whether justly or otherwise, will fall on engineers, and it behooves us as a duty alike to the public and to the profession to inquire into the causes and conditions of the disaster. The undeniable fact is that we have in the United States so long a list of dams which have failed under extreme high water that there ought to be a systematic investigation of these cases and comparisons of them with a large number of other cases in which dams have withstood floods. The right kind of study would, we believe, go far toward determining whether or not there are certain fundamental considerations common to these failures, due recognition of which would have avoided catastrophe.

The editor believes that fundamentals have been overlooked in very many cases—as well among structures which have fortunately survived as among those which have failed. Structural analysis and design are not the fields in which we would first search; nor would be begin with foundations and ground conditions, difficult as are the problems thereof. We think that the very first consideration should be what would happen in case the dam should fail; and if human life is to be endangered the problem will require a different treatment than otherwise.

It is usually possible to design and build a structure massive enough to withstand any conceivable flood. It is by no means always economic to do so. Paris could be protected against further damage from the River Seine, but it has been stated on apparently good authority that the interest on the cost of such protection would greatly exceed the losses due to the floods, which occur only at long intervals of years. Corresponding cases on smaller scales are numerous. These are economic problems and are to be solved as such. The chances of disaster are to be computed as well as may be; the cost of possible disaster is to be estimated; and out of the possible designs ranging from that affording complete security to the one having a minimum factor of safety, that design is to be chosen which shows the maximum net economy. If innocent parties are subject to injury in case of accident it is only just that they have some guarantee of reimbursement, but that is a matter of law rather than of engineering.

Just how far human life should be safeguarded neither the editor nor any other man can say—nor can we measure a life's worth in money. All the computations of economists as to the worth of a man to society, and all the court awards that were ever made for accidental deaths are mere ratings in terms of food and shelter, and afford no measure whatever of that which was held dearest and was lost. Yet to make preservation of life our only aim would be to make life not worth preserving; and so we must go on with works which the laws of chance tell us will inevitably cost life while in progress, and which in some instances will menace life after completion. Witness most conspicuously the automobile.

Out of this more or less philosophical consideration we can get no quantitative answer to our problem; but we can let it lead to the question: "Are we applying no more care and no higher factors of safety to the protection of human life, and especially of human life in large numbers, than we are to the protection of property?" We ask this without forgetting that lives depend on most engineering designs; and we are brought immediately to the other question—"Are our factors of safety high enough on all our works?" The dam failures afford a negative answer.

It will be claimed in behalf of the designers of these structures that they provided for all contingencies which man could be expected to foresee, and that to go further would be to adopt an extreme of caution out of proportion to the caution exercised on other works. It is with this last point of view that, as the editor sees it, the greatest fault lies. To take one comparative case only—the respective problems of bridge and dam design differ conspicuously in two important elements—the forces, or loads, which the structures are to carry, and the bond or junction of the foundation with the natural material of the earth.

The [illegible] on bridges are [illegible] definitely known. Even wind loads are provided for at a maximum exceeded only by tornadoes; and tornadoes and earthquakes are forces against which our designs seldom even pretend to provide. The time may come when they will be given more attention. But the case of the dam is often very different. It is impossible to say how high the water may rise; its possible velocity is a matter of some uncertainty; and the impact with which it may drive debris against the dam is a function of so many elements as to be practically unknown.

Foundation bonds present much the same case. Except for arches the bridge loads are chiefly vertical, and the subsoil has merely to carry compression. Failures, when they occur, are usually so slow as to make no menace to life or property. But the horizontal forces acting on a dam, uncertain themselves, are to be met by uncertain resistances in the bond between the foundation and the earth, and in the shearing strength of the earth; and if a yield starts it progresses almost instantly to complete failure. So too, if an earth dam is overtopped through lack of spillway capacity or otherwise, swift disaster is the sequel

A single dam failure may cost more lives than all the bridge failures of recent times. This alone calls for a larger relative safety factor on dam than on bridge. Long ago a shrewd professor remarked that the term "factor of safety" is a euphemism that in reality we are dealing with a "factor of ignorance." Some designers of dams (too many, we fear) have yet to learn that it is their duty to apply larger "factors of ignorance"—that numbers of men may not die through the cocksureness of one in his judgment and his calculations.

It is not unfitting to here call attention to Galveston's sea wall. Ten years or more ago we heard its design criticised as needlessly extravagant. It may be stronger than necessary; we doubt if the designer himself could say whether so or not; but the forces to which it may be subjected are still unknown. In 1915 it received a test more severe than had been anticipated it should ever have. Not only was it battered from the outside by the worst storm in the history of Galveston, but at different points the highway pavement on its inner side was broken through and the filling back of it washed away, leaving considerable spaces of the structure unsupported from behind. It may contain unnecessary thousands of yards of concrete and tons of steel, but one shudders to think of what might have happened to a less generous design.

Manufactured Outputs 1919 and 1914

The Bureau of Census has just issued a preliminary statement of the value of products manufactured in 1919 as compared with 1914. The respective totals are $62,589,000,000 and $24,246,000,000. But in order to make a comparison that will have any real significance we must take into consideration the change in the level of wholesale commodity prices. According to the Bureau of Labor the wholesale price index was 212 for the year 1919 and 99 for 1914, as compared with 100 for 1913. Hence if we divide the $62,589 millions by 212 per cent (or 2.12) we get $29,500 millions; and if we divide $24,246 by 99 per cent we get $24,500 millions. Hence when reduced to the price level of the year 1913 (the prewar level), the output of manufactured products during 1919 was $5,000 millions, or 20.4 per cent in excess of that during 1914. This disposes finally and completely of the contention that the high price level of 1919 was due to subnormal production.

In Engineering and Contracting, May 5, 1920, it was shown that during 1919 the excess of our exports over imports was $4,007 millions, which divided by 212 per cent (the commodity price index for 1919) is $1,900 millions.

In Engineering and Contracting, April 7, 1920, Mr. Gillette showed that the "value added by manufacturing (i. e., the difference between the cost of the raw materials and the selling price of the finished product) is about 40 per cent of the selling price of the finished product; also that the "value added by manufacturing" is slightly in excess of the value of farm products and minerals. Hence it follows that the value of manufactured products for 1919 must be substantially equal to the combined value of the "value added by manufacturing," the value of farm products and the value of minerals. This being so the excess of exports over imports during 1919 was only 7 per cent of the total wholesale productivity. Therefore, even after deducting this percentage, our national per capita production that was available for domestic consumption was greater in 1919 than in 1914. This is the conclusion that Mr. Gillette reached in the articles above mentioned, although at the time of their publication, the results of the 1919 census were not available.

The Census Bureau classifies manufacturing industries under 250 heads, from which we have selected the following 51 as being the ones most likely to interest our readers. The value of manufactured product is given in millions of dollars.

	1919.	1914.
Automobile bodies and parts	$ 671	$130
Automobiles	2,388	503
Belting and hose, rubber	26	24
Belting and hose, other than rubber	19	4
Belting, leather	41	23
Brass, bronze and copper products	488	162
Brick and tile, terra-cotta and fire-clay products	211	136
Carriage and wagon materials	27	25
Carriages and wagons, including repairs	92	107
Cars, electric railroad, not including operations of railroad companies	18	10
Cars, steam railroad, not including operations of railroad companies	540	195
Cement	171	102
Copper, tin and sheet-iron work	161	95
Electrical machinery, apparatus and supplies	884	335
Engines, steam, gas and water	465	72
Explosives	92	41
Foundry and machine-shop products	2,321	867
Gas machines and gas and water meters	27	15
Hardware	145	73
Instruments, professional and scientific	58	17
Iron and steel, blast furnaces	794	318
Iron and steel, steel works and rolling mills	2,813	919
Iron and steel, cast iron pipe	50	27
Iron and steel doors and shutters	11	5
Iron and steel, nails and spikes cut and wrought, including wire nails, not made in steel work or rolling mills	18	7
Iron and steel, wrought pipe	84	38
Lime	37	18
Locomotives, not made by railroad companies	156	43
Lumber and timber products	1,400	715
Lumber, planing-mill products, not including planing mills connected with saw mills	561	208
Marble and stone work	128	107
Paints	256	112
Paper and wood pulp	794	332
Paving materials	44	63
Plumbers' supplies, not elsewhere specified	58	43
Pumps, not including power pumps	32	6
Pumps, steam and other power	54	18
Roofing materials	86	28
Saddlery and harness	154	54
Shipbuilding, steel	1,454	66
Shipbuilding, wooden, including boat building	168	22
Smelting and refining, copper	633	444
Smelting and refining, lead	193	172
Smelting and refining zinc	103	54
Steam fittings and steam and hot water heating apparatus	161	64
Stoves and hot-air furnaces	146	68
Structural ironwork, not made in steel works or rolling mills	305	159
Wall paper, not made in paper mills	23	16
Wall plaster and composition flooring	27	17
Wire	162	82
Wirework, including wire rope and cable, not elsewhere specified	91	42

The Cause of "Cloud Bursts"

Five hundred lives have just been lost and $10,000,000 worth of property destroyed at Pueblo, Col., by a "cloud burst," according to press reports. Doubtless many people still believe in the old theory that sometimes clouds instantaneously release the water that they carry, instead of following their usual custom of acting like a sprinkling pot. But few even of those that know this ancient theory of sudden floods to be false are able to explain the causes of the phenomenon called a "cloud burst."

"Cloud bursts" occur only in or near hilly or mountainous areas, and are most frequent in arid regions. The conditions necessary for a "cloud burst" are: First, a very heavy downpour of rain for several hours; second, a steep water shed; and, third, a soil that does not rapidly absorb the water.

Clayey soil that has been baked hard by the sun is a condition ideal for very rapid run-off following a rain. Such soils are common in arid regions.

When rain begins to fall more rapidly than the soil can absorb it the first thin sheet of water that flows down the water courses moves slowly, because the friction of the water is proportionately greater the shallower the stream. The friction acts like a dam, holding the stream back. Hence it follows that the water tends to bank up, so that the rain that fell first is overtaken by rain that fell many minutes later. The deeper the stream, the faster it flows, for the frictional resistance is then proportionately less. Consequently the time comes when the flood moves rapidly down the water course, its front crest often being several feet deep and looking like a huge sea wave about to break on a shore. The writer has seen such a flood approaching at the rate of eight miles an hour, filling a previously dry creek channel to a depth of 10 ft.—a veritable wall of water.

In the early speculations about such floods it was perhaps natural to suppose that a cloud had suddenly spilled its entire contents, even as a bursting dam might release its stored water. It was not realized that the friction of water upon earth could produce the effect of a dam, holding back the first part of a rainfall until the more rapidly moving water that had fallen later had overtaken it, thus forming a wall of water several feet deep.

It is stated that 2.92 in. of rain fell at Pueblo during 24 hours, but that even greater precipitation occurred near Swallows, 20 miles up the Arkansas River. About four hours after the first downpour at Swallows a wall of water 10 ft. high reached Pueblo. The lower part of Pueblo was suddenly inundated, buildings and bridges were swept away, and several hundred people drowned. Warnings had been sent out to most of the residents by telephone, but it is evident that many people did not realize the seriousness of the flood that was coming.

The Arkansas River above Pueblo is a mountain stream, fed by many creeks. The soil through which it flows near Pueblo is a clay that had been baked hard. An exceptionally heavy rainfall over a large area occurred. These are the conditions above enumerated as existing whenever a cloud "bursts."

A Misused Word Causes a Riot

Law suits over the meaning of words are of every day occurrence; prolonged and acrimonious disputes over definitions have marked the progress of every science; but it has rarely happened that a misunderstood word has caused the death of hundreds of people. Yet, according to press reports, the recent bloody riot at Tulsa, Okla., was due to the use of the word "assault" which was misinterpreted to mean "rape."

A white girl had slapped a negro who had grasped her arm and throat. She filed a charge of "assault and battery." A paper spoke of the incident as an "assault." Many readers thought that "rape" was meant, and a "lynching bee" was organized. The "bee" ended in a race riot and the killing of many people.

It has been the custom of newspapers to avoid the use of the word "rape," using instead, either "attack" or "assault," neither of which should ever have been used where "rape" was meant. The prudery that originally led to the misuse of the words "assault" and "attack" has finally resulted in the killing many innocent people. It would be hard to cite a better instance of the importance of always using words in their proper sense.

Municipal Use of Water at Springfield, Mass.—The value of the water service furnished in 1920 to the various departments of the city of Springfield, Mass., amounted to $76,459, according to the 40th annual report of the Water Commissioners. Payment for this service, however, is prohibited by city ordinance. The distribution is shown in the accompanying tabulation:

Classification	Amounts.	Gallons	
Schools	$10,740.75	156,838,713	93% metered
Public buildings (except schools)	3,520.80	59,740,736	89.9% metered
Public parks	3,712.10	55,588,571	78.4% metered
Public playgrounds	148.00	2,220,222	Unmetered
Building purposes (Streets and Engineering Department)	243.75	3,656,615	Unmetered
Sewer Department (flushing)	6,410.00	96,159,159	Unmetered
Snow removal	1,727.34	25,910,000	Metered
Street flushing	1,437.00	21,557,156	Unmetered
Watering tanks and drinking fountains	644.30	9,515,278	7% metered
Total of above	$28,584.04	431,186,450	
Fire hydrant service	47,875.00		At $25 per hydrant
Total municipal use	$76,459.04		

Unmetered quantities in gallons are estimated from amounts, on basis of 6⅔ ct. per 1,000 gal.—or equivalent of 5 ct. per 100 cu. ft.—per cent metered is computed on quantities.

The installation of meters on some on the principal municipal services, to the extent as shown in the foregoing tabulation, has called attention of the city authorities in tangible form to the extravagant and unnecessary waste of filtered water in many of the municipal buildings, and has resulted in large reduction of such waste in past years.

A Chance for Engineering Promotion Work

To the Editor: In thinking over the present business depression and its effect on the engineer, it occurred to the writer that a little promotion work on the part of the engineer might alleviate his troubles.

The engineer of today stands in a most peculiar situation from a business point of view. He has something to sell that is needed more today than ever before, but his "sales" are at the lowest ebb they have reached in years. If this were true of some manufactured commodity it wouldn't take the manufacturer long to get out and do some sales promotion work. For some reason engineers don't seem to take this attitude toward their "market"—the promotion of engineering projects is left to someone else. This fact is not so serious when the project is a scheme that will make money for some corporation or group of capitalists, because in this case the work will be instituted by those interested in its operation. With public improvements, however, we deal with an altogether different proposition. As a rule they are "everybody's business" and get little attention from Mr. Private Citizen until the sewer system, the pavements, or the water supply reach the point where their condition annoys him. As long as the ordinary citizen is able to get his water delivered at the fixtures in his house he cares little about the pumps or mains. The fact that the pumps are continuously operating under full or excess load, and that small mains are made to carry such volumes of water that friction losses make high station pressure necessary, is of little interest to him. Finally the limit of their capacity is reached, and the cry goes up for improvements. Improvements take time, and a period of annoying low pressure is grudgingly endured while they are being made.

Again, consider the small-town waterworks. We find a town with a population of 300 supplied with water from a public water works, and again a town of 1,500 that still uses hand-pumps. If the smaller town can afford a public waterworks, it is a certainty that the larger town can. What then is the reason for the absence of a waterworks in a larger town? It is simply this: Nobody has made an effort to sell waterworks to the latter town. Pump and tank manufacturers may have attempted to interest them in waterworks, but having something to sell their arguments are sometimes looked upon as those of a man "with an ax to grind" and are apt to be considered accordingly. The proposition of installing a waterworks put up to them by an engineer capable of explaining the advantages of having a public water supply will often be effective, where arguments by equipment salesmen have failed. The arguments in favor of public water supply are so numerous and so convincing that if properly presented to the ordinary town council they could not fail to see the advisability of constructing a water system. The fact that a public water supply lowers the death rate and promotes good health is borne out by statistics compiled by numerous state health departments. The loss due to fire in small towns is a matter of common knowledge, and when properly presented will offer a convincing argument in favor of water supply. Again the need of a water supply for industries that might be attracted to a town can also be used to advantage.

Here is a chance for engineering promotion work. Why not let towns where public works are in the condition described above know the result of delay and the need for improvements now? The cessation of public improvements during the war has left many growing communities in this position, and others will shortly experience the trials that come to the town that does not keep its public works up to the point required by its growth. In addition to the public improvements that go on annually under ordinary conditions, there are four years of work that have been delayed by the war that remain to be done. The result is a very fertile field for engineering work. Engineers should get busy and promote public improvements to provide, not only a field for their services, but to avoid the dangers to the community that result from delay.

In the face of such conditions the failure of engineers to speed their return to "normalcy" or better will be due to the lack of a little energetic promotion work.

THOMAS F. WOLFE.

A Suggestion to Authors of Technical Programs

[illegible] in the nature of a personal [illegible] excellent and estimable persons who read papers at scientific society meetings. Without their zeal and enthusiasm we would have no formal technical programs, and but for their personal interest in science we would not have nearly so wide a dissemination of technical knowledge. Curiously enough, however, they frequently lack the quality of salesmanship which would greatly enhance their value to their audience. They do not know how to present the ideas which they have carefully recorded after painstaking thought, research and investigation. About twice a year following the spring and fall seasons of scientific and technical conventions, we have been tempted to express our feelings on this subject, not in unkind criticism, but by way of friendly advice and suggestion. Probably this is because it falls to the lot of editors not only to attend but also to report a great many meetings, and consequently their feelings on this subject are more intense than are those of the average attendant.

In the first place there are few technical papers that will bear reading verbatim to an audience. The literary style in which they are couched is far better adapted to quiet perusal in printed form. What the audience is most interested in may be phrased expressively, if inelegantly, by the query, 'What's it all about?" In other words, there is, or should be, an important feature, result or conclusion which summarizes the author's contribution and which can be told in simple language in conversational style. It is not expecting too much of an author to ask that he shall be sufficiently familiar with his subject to be able to review and summarize his paper extemporaneously and relieve his audience of the impossible task of following him through a formal reading. This is particularly true when chemical equations, mathematical formulæ or tabulated data are to be presented. A few lantern slides and a 5-minute explanatory talk will frequently tell the whole story better than a 20-minute formal reading which leaves the audience confused. It is a matter of simple observation that the author who best transmits his ideas to his audience does so through these simple expedients; and it may be worth noting that our convictions in the matter are shared and openly expressed by those thoughtful persons trying to get the most out of their attendance on conventions.—Editorial in Chemical and Metallurgical Engineering.

Research and Engineers

Industrial research is a broadening field of work for engineers. For research men, from the very nature of the work, must be analytical, accurate, and have the thorough comprehension of the potential possibilities in the better utilization of the forces of nature that comes from continuous, intensive study of materials and their application to the work of mankind. The training of engineers, from the very beginning, leads toward research work.

The day of the inventor who worked alone on some brilliant idea is passing. The volume of scientific knowledge is too large for one man to grasp. Hence we have seen grow up within the last two decades the co-ordinated research laboratory in which many specialists are employed. Here the knowledge of one engineer supplements the study of another, and difficult problems are worked out in conference.

There are many laboratories of this type, among them the research organizations of the General Electric Co. and the Western Electric Co.; the vast laboratories of Edison, who was a pioneer in co-ordinated research; Arthur D. Little, among other consulting organizations; and in Government work, the Bureau of Standards, and the smaller but effective organizations of the Bureau of Public Roads, and the Forest Products Laboratory. The universities have also been forward-looking in research and many underpaid teachers of engineering have accomplished far-reaching work. The recent work of the Massachusetts Institute of Technology is particularly noteworthy.

The primary object in the organization of the Engineering Foundation was research work, and it was endowed largely for that purpose. It has a broad field of work ahead. The National Research Council, which is directed for the most part by engineers, is another research organization that has great possibilities for usefulness.

Taken by and large, the development of enginering industrial research is one of the most potent factors in the growth of prosperity. It is as much an engineering work to translate technical knowledge into the industrial power that comes from better methods of making steel rails or more durable highways, as it is to produce power from steam or electric energy.—Editorial in the Professional Engineer.

Edison's Test of Education

By the criticisms of the long list of questions compiled by Thomas A. Edison as a test of the eligibility of applicants for positions in his East Orange works a wide diversity of opinion as to what a college graduate should know has been divulged. If it was the purpose of Mr. Edison to test the efficiency of the college curriculum, we cannot indorse the method he employed. If, on the other hand, he aimed to test the kind and extent of the applicant's reading, his power of observation and the retaining power of his memory, the test is sufficiently comprehensive to be fair. From this standpoint it would effectively reveal a disposition to "bluff" and make wild guesses as compared with a disposition to be specific and accurate in expressing facts and ideas. Aside from these viewpoints, Mr. Edison's questions have definitely raised the question, What is education? We agree with the comment of one critic that frequently the college graduate believes his diploma is a certified check on the bank of wisdom, while in fact it is simply an invitation to open an account. For this class of men Mr. Edison's questions have provided an effective means of introspection that can be used by non-college men as well as by those who have earned a college degree. If the result has induced the purchase and a new study of the dictionary, the encyclopedia and works of history, a great good has been accomplished. It is a good thing to take stock of our ready knowledge from time to time, and if Mr. Edison has furnished the incentive, his great genius should receive another credit mark. When a realization is brought about of the importance of looking thoughtfully at life and its practical problems, of mentally cataloguing information for ready reference and of regularly adding to the storehouse of knowledge as periodical inspections and experience show a lack of it, then and only then can any one lay claim to education, whether he be a college man or one who has been less fortunate.—Editorial in The Electrical World.

Another Coal Crisis?

In every year for four years the transportation and business of the country have been demoralized by demands that the railroads should in certain periods to prevent a coal shortage handle more coal than they are physically capable of handling The railroads and the Interstate Commerce Commission should definitely announce at an early date in terms leaving no possibility of misunderstanding, that no priority will be given to coal this year, no matter what may became the alleged necessities of coal producers and consumers, or of those of any section. The railroads can transport all the coal the country needs if given opportunity to handle it in reasonably uniform volume, and if the stupidity and selfishness of the coal producers, dealers and consumers which have caused one coal crisis after another cause another this year, their stupidity and selfishness should be allowed to produce their natural results. The railroads should cease to be made the "goat" for these coal crises.

Meantime, where are the construction concerns which made such a howl last summer when, owing to priority being given to coal, they could not get enough cars to ship materials? Why are not they "shipping early" in some of the 175,000 open top cars now standing idle? A few months ago when the railways were moving the largest volume of freight ever handled, many people were charging they had "broken down" because they did not move more. Now, when over one-third of the railroad capacity of the country is idle, many people are saying private operation has "broken down" because with this enormously reduced traffic the railways are facing a financial crisis. The most varied and bitter experience does not seem to teach the American people anything regarding transportation matters.—From an editorial in Railway Age.

The Aerocamera in the Service of the Engineer

By E. H. CORLETT,
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Much has been written and still more has been said as to the extent to which the aerophoto will shorten and cheapen engineering operations. Most of it has been plain fantasy, but there remains certain fields of true usefulness, and it is my intention herein to present some facts which may aid engineers in conceiving such uses of the method and prevent them from expecting the impossible of it.

Adjustment in the Laboratory Eliminates Horizontal Perspective.—The aerophotomap, or aeromap, can never be more than a series of views, even when made into a mosaic. It is the aim of the camera operator to have the camera horizontal (that is, pointed vertically downward) at the instant of exposure, but as matter of fact there is at present no method that enables the operator to be positive that his instrument is more than within rather wide limits of this position. If the camera is not horizontal, the picture taken will show horizontal perspective. However, by checking against points of known location, the picture can be dealt with so as to eliminate a large amount of this perspective. In the same operation, it can be brought to any desired scale, subject to certain conditions. We shall henceforth assume that the aerophoto is free of horizontal perspective, either by accident of taking or by technique of correction.

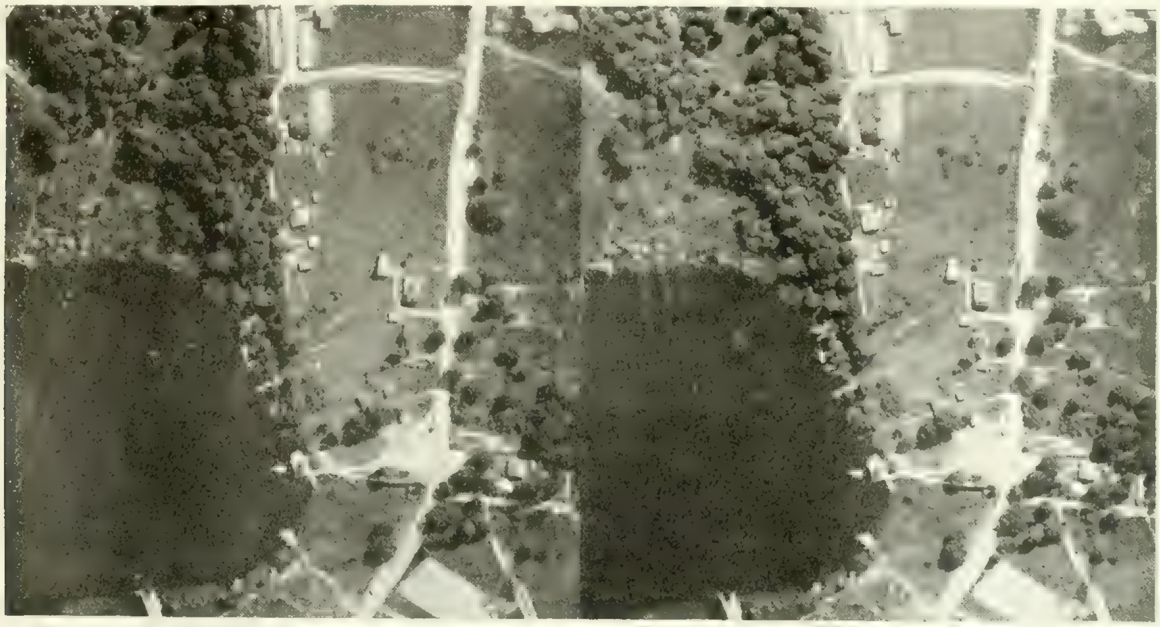


Fig. 1.—South End Geauga Lake, Portage County, Ohio. Scale About 1 in. to 430 Ft.
(Cut this out, paste it on a card, and try it in your stereoscope.)

"Lean" and Displacement.—The aerophoto can give true plan views only of objects which are small in vertical dimension. It is a composite plan view of all objects upon a series of planes, infinite in number and of scale that decreases with the distance from the camera. The scale along the 1,000 ft. contour is less than the scale along the 1,200-ft. contour by an amount that is proportional to the altitude of the aeroplane over each contour. Stated more simply: all objects have a "lean" that varies directly with both the elevation of the object above whatever datum plane is assumed and the distance of the object from the point over which the camera was located when the photo was "shot"; and that varies indirectly, approximately, with the altitude above the datum plane at which the photo was taken. When we see, on the aerophoto any object, like a building or a tree or a steep bank, the nature of which indicates by inspection its shape, we see its "lean" and we do not care how much it leans. However, we can not "see" the displacement of a hilltop where the slopes are gentle; neither can we ever expect to correct such displacement.

Adjusting Displacement.—This displacement is often called "error"; it is not that, but a very simple function of three variables, only one of which can be obtained with what an engineer would call exactness, but all three of which can be easily and sufficiently approximated for his purpose. The best that can be done is to render the aerophoto true to scale on some one datum plane which approximates the part of the terrain photographed in which the user is mainly interested. Then, if he knows the elevation of any object with respect to this datum plane, either by direct observation, by U. S. G. S. sheet, or by inspection and estimation, its true position can be platted, either for direct use or for transference as closely as he will ever scale any engineering map. For instance, assume a level plain and a hill actually 100 ft. high but shown on a U. S. sheet as 120 ft. high. Suppose the image of the summit of this hill is 3.27 in. from the point on the picture vertically below the camera, which is approximately 4,800 ft. above the plain. Then the actual displacement of the hill summit will be almost exactly 0.017 in., while its calculated displacement will be 0.084 in., a difference of 0.014 in., or 5.6 ft. in a scale distance of about 1,300 ft.

With the proper equipment it is very seldom that the point vertically under the camera on the aerophoto will be more than an inch from the center of the aerophoto as determined by the intersection of its diagonals. Assume further, in the case above, that this point is an inch away from the point assumed and in a direction such as to make a maximum of the error contingent upon its false assumption. This will increase the 5.6 ft. by about a third of itself to 7.5 ft., or to less than one-fiftieth of an inch on the print. This is not much of an error in that distance, and any draftsman can be taught to apply the correction. Furthermore, it must be remembered that this same hill summit will scale true, as close as any engineer will ever wish to scale a paper map, with respect to the rest of the hill—the scale of the summit itself being 392 ft. = 1 in. From this it is easy to see that two aerophotos covering the same area (at the east edge of one picture and at the west edge of the other) can not be expected to match at all points. Each aerophoto has vertical perspective, the vanishing point being the point vertically below the camera at the instant of exposure. However, by a judicious choice of a separate datum plane for each aerophoto (and sometimes it is advisable to split the area into segments each to be allotted a different datum plane), annoyance from lack of continuity due to relief is brought to a minimum so small that it ceases to be an annoyance once its nature is understood.

The Aerostereograph and Its Uses.—There is now to be considered a fact which makes the displacement due to relief a blessing instead of a curse. Wherever two aerophotos cover the same area from points approximately at the same altitude and separated horizontally by a distance equal to an appreciable fraction of that altitude, we are given the privilege of examining that terrain stereoscopically. By means of the

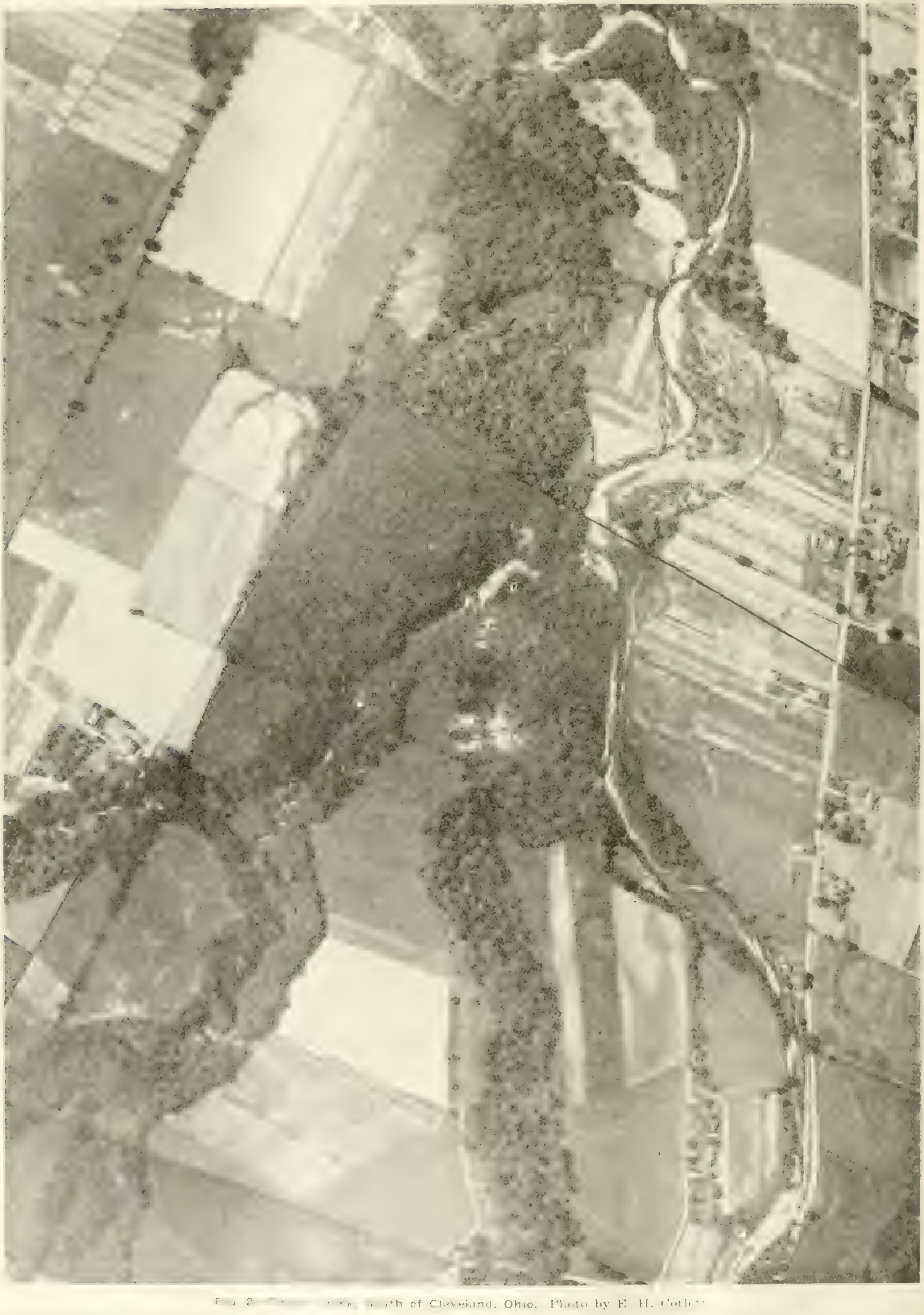


Fig. 2—[illegible] south of Cleveland, Ohio. Photo by E. H. [illegible]
(Notice railway cut, fill and trestle crossing the picture near the bottom. Bare earth photographs white. The joining illustrates poor overlap and excessive stagger.)

aerostereo, one sees relief—exaggerated, but always truly proportional within any one area of overlap. It is no idle dream that refinement of technique, already foreshadowed, will enable us to contour with a fair degree of accuracy any portion of the terrain which yields photographic contrast of detail sufficient to enable us to see the ground. Even uncontoured, the aerostereo is more graphic than any except a relief map can be; and no relief map can ever be made to record the detail registered by the aerocamera. The man at the head of a business is often one who has not had the time to learn to read exactly and quickly even the best of topographic maps. For him the aerostereo is a record of conditions as they are. Besides all this, the aerostereo enables one to estimate relief closely enough to apply the corrections necessary in making a map out of the individual aerophotos.

Limits of Error.—Under the worst conditions it may be assumed that the aerocamera will record the existence of objects that subtend at the camera an angle of 0° — 01′; or that indicate a largest dimension of 0.004 X the scale of the aerophoto. Under the best conditions, the ratio should be about 0.0001 X the scale. However, small objects can not be scaled from the aerophoto because, under the microscope, there will always appear some blur, due to either the velocity of the aeroplane or the grain of the emulsion or both. By small objects, I mean those the dimensions of which are comparable with the distance the aeroplane travels while any portion of the film is being exposed. Practical shutter speeds in mapping cameras range from one one-hundredth to one three-hundredth of a second.

With the difficulties at present existing with uneven shrinking and swelling of photographic material, it is best to expect a maximum error on the datum plane of any individually correct aerophoto of not less than 1 per cent of any designated scale. One can expect the separate aerophotos of which a mosaic is made, called the "elements," to be placed and oriented with an error slightly greater than that hidden in the net used for controls. This means that on over-all dimension this aero map will be accurate in proportion to the amount the user can afford to pay for controls. At one extreme this will require a skeleton survey of more or less ramification. At the other extreme will be the terrain of which there is no existing map. It is extremely unlikely that the value of such an area will be great enough to justify an elaborate system of controls. In such a case, we check the altimeter either by a test figure or by transit observation often enough to enable us to be reasonably certain that the camera is being carried at an elevation above the terrain that will yield us negatives on a scale desired. Then the principle of balanced loops, with a few modifications, applies. It is likely that such an aero map will be true in over-all and internal dimension within 2 per cent of actual. Between these two extremes lies the field where the aerophoto will find its most extensive use for some time. This is the terrain which has been mapped with more or less thoroughness before. Here the aero map will be just as good as most land survey maps; and in detail, infinitely better.

Cost of Aero Surveys.—The camera can cover a large area on a good day; but the frequency of good days depends upon locality and season—and luck. Allowing two hours at a practical altitude, the aerocamera, provided everything works right—and this includes personnel as well as equipment—will record information of about 150 square miles of terrain with sufficient overlap to permit stereoscopic inspection of any point thereon.

Cost is a matter of some doubt. For purposes of comparisons, I list what I believe to be fair. The assumption is here made that negatives on a scale of 500 ft. to 1 in. and a mosaic on the same scale, will comprise the finished aero map. For a mosaic embodying the best practical correction allow a fixed charge of $2,000 plus a rate charge of $130 per square mile. For a mosaic without controls of any sort, survey or map, allow a fixed charge of $1,000 plus a rate charge of $10 per square mile. Both of these costs may vary widely, both above and below the figures given. For areas below 10 square miles, the costs will not follow just the system described, but nearly enough for comparisons. Nothing but a most careful consideration of needs and local conditions will justify fixing definitely the cost fairly to be charged to the production of an aero map.

Uses of Aero Surveys.—It would be rather presumptuous for any one engineer to essay to tell the profession as a whole just where and when the aero map would be of use to it. I am assuming that the engineer who has read the first part of this article will, through realizing the theory and practice so briefly set out, be more able to conceive of whether or not the method would help him in certain situations than I would be in listing such situations. However, I will suggest one:

Let us assume that a certain valley is under consideration as the possible location of a storage basin. It is more than likely that valuable property is going to be submerged if the valley is flooded. This property may be that of the United States—as timber, grazing land, or possible farm land; it may be the property of a prosperous municipality together with the properties of its citizens. A boundary survey alone will give with sufficient accuracy the areas involved. However, the aerophoto will supply quickly and cheaply evidence that can not be attacked as to the nature of the properties—be they industrial, residential, agricultural, or virgin. After the highwater line has been run, it is likely that highways, railroads, and maybe even canals, will require relocation and building. A strip aeromap, supplemented by aerostereos, will supply a fair share of the information as to where to make the relocation and practically all the information as to where not to make it. Of course, the details of exact location will be supplied by survey. The same applies to damsite locations.

A stereo on a scale of 1,000 ft. to 1 in. will include an area of 2,700 ft. by 3,200 ft. and offers a chance for very comprehensive studies of the terrain embraced. Quite often the powers behind such a project are not, through training, equipped to get the most out of even a very carefully prepared contour map. They can, however, understand the aerostereo because they see what is actually there; and when they see an aerostereo and a contour map they have before them information quickly and cheaply obtained and conclusive in its nature.

Avoiding Trespass.—To summarize: Properly used, the aerocamera offers the engineer information accurate enough and cheap enough and of such value in reducing his field operations as to make it worth while. Furthermore, there is no such thing as aerial trespass. Against the aeroplane and the aerocamera, the belligerent squatter and the "superior" country gentleman are equally powerless—legally as well as physically. In the main I assume that the aeromap will be used to give the engineer the choice of the areas or lines he wishes to map precisely. As improvements are made this method will grow more precise and more reliable in time peformance. For the immediate future the value of the aerophoto to the engineer will be exactly proportional to two variables: first, to the degree in which the possibilities inherent in the process are co-ordinated to the actual needs of the engineer; second, to the willingness and ability of the engineer to realize these possibilities and to aid the aeromapper in making practical application of them.

Underground Water in Connecticut.—A survey of the ground-water resources of Connecticut is being made by the U. S. Geological Survey, Department of the Interior, in cooperation with the Connecticut State Geological and Natural History Survey, the results of which are being published in a series of water supply papers. The sixth paper in this series, recently issued, was prepared by H. S. Palmer. It covers what is called the Southington-Granby area, which lies partly in the Central Lowland and partly in the Western Highland, and extends from the Massachusetts State line nearly to the coast. This area includes 18 towns and occupies more than 500 square miles. The report contains 219 pages and two detailed maps showing the geologic and hydrologic features of the area. It includes a description of the water resources of each town. Copies of this report, which is issued as Water Supply Paper 466, can be obtained free of charge by writing to the Director of the U. S. Geological Survey, Washington, D. C.

Am. Soc. C. E. Has Over 10,000 Members.—On May 5 last the membership of the American Society of Civil Engineers was 10,010. On Dec. 2, 1920, the figure was 9,870, and the total membership as reported each month for the year 1921 is as follows:

January 6th	9,912
February 3d	9,874
March 3d	9,889
April 7th	9,971
May 5th	10,010

A Page from Recent Waterworks Reports

Leaks in Water Mains at Springfield, Mass.—During 1920 there were 33 leaks in the water pipe [illegible] system of Springfield, Mass., an average [illegible] per mile of main pipe in use. Eighteen of these leaks were at defective joints, three were broken sleeves, five were from cracked, five were at hydrant connections, one was the blowing out of an 8-in. plug, one a piece of pipe burst.

Water Consumption in 1920 in the Metropolitan District of Massachusetts. The following table from the report of Frank E. Merrill, Water Commissioner of Somerville, Mass., for 1920, shows the consumption of water in cities and towns in the Metropolitan Water District for the year 1920 as registered by the Metropolitan meters:

City or Town	Total per day Gal.	Per capita per day Gal.	Per cent. services metered.
Medford	[illegible]	[illegible]	100
Milton	[illegible]	[illegible]	100
Belmont	[illegible]	[illegible]	100
Arlington	[illegible]	[illegible]	100
Winthrop	[illegible]	[illegible]	100
Malden	[illegible]	[illegible]	97
Melrose	1,108,100	61	100
Lexington	424,200	66	100
Revere	[illegible]	68	79
Chelsea	[illegible]	[illegible]	99
Somerville	[illegible]	[illegible]	77
Swampscott	657,200	81	100
Everett	[illegible]	86	68
Watertown	[illegible]	[illegible]	100
Quincy	[illegible]	93	90
Stoneham	600,100	[illegible]	99
Boston	94,297,400	125	74
Nahant	192,600	145	75
Total district	127,265,500	105	74

Cost of Chemicals for Water Purification Plant of Columbus, O.—The accompanying tabulation reprinted from the 50th annual report of the Division of Water of Columbus, O., covering the year ending Dec. 31, 1920, shows the quantities and cost of chemicals used at the city water purification plant for the period 1909 to 1920 inclusive:

QUANTITIES AND COST OF CHEMICALS USED (COMPARATIVE) PRICES F. O. B. COLUMBUS

	Lime		Soda Ash		Alum		Bleach	
Year.	Tons.	Cost per Ton.	Tons.	Cost per Ton	Tons.	Cost per Ton.	Tons.	Cost per Ton.
1909	[illegible]	$5.75	1,492	$17.50	[illegible]	$19.00		$....
1910	3,081	5.80	[illegible]	17.50	123	18.00	.	...
1911	[illegible]	5.12	1,776	17.50	590	17.50		...
1912	3,296	5.27	1,583	15.20	[illegible]	17.15	22	27.80
1913	3,629	5.17	2,895	12.88	711	17.10	17	27.80
1914	[illegible]	5.27	3,540	13.30	880	16.75	14	29.20
1915	3,970	5.17	2,383	15.14	[illegible]	†16.60	22	34.80
		...		...	[illegible]	*7.27		.....
1916	4,550	5.17	1,975	62.00	[illegible]	20.08	19	85.00
1917	4,206	7.03	1,833	60.00	[illegible]	*10.69	24	70.00
1918	4,810	9.22	3,005	58.60	1,113	*14.62	25	54.56
1919	5,149	10.21	2,748	40.50	1,156	[illegible]	15	60.00
1920	5,387	11.90	2,149	43.60	1,394	*15.52	23	67.72

[illegible] per ton based on open market. †Bauxite cost $13.85 [illegible] Columbus, O., 1920. Cost of materials. Sulphuric acid cost $20.00 ton, f. o. b. Columbus, O., 1920.

Cost of Operating Ford Runabouts in Water Department Service at Pasadena, Calif.—The average cost of operating Ford runabouts by the water department of Pasadena, Calif., was 5.6 ct. per mile in 1920, according to annual report of the department for that year. The department has 9 cars of this type, and the average mileage made by each was 7,791 miles. The average hours in service was 1,962, and the cost per hour was 22.3 ct. On an average a car made 14.7 miles on 1 gal. of gas and 468 miles on a gallon of oil. The average unit costs for the 9 cars were as follows:

	Cost per mile.
Tires and tubes	$0.0097
[illegible]	.0150
Other material	.0051
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
Depreciation	.0116
[illegible]	[illegible]

Machine Trenching and Back Filling by a Water Department.—Early last year the Water Commissioners of Springfield, Mass., purchased a trenching machine and a back filling machine. The results obtained with this equipment are set forth as follows in the 47th annual report of the Commissioners covering the year 1920:

[illegible] in keeping, for the labor question, while not quite so bad as during the previous year, has nevertheless not been at all what it used to be, and notwithstanding we have paid the highest wages of any department of the city, only a limited force of men could be maintained.

In the line of improvement work, our largest job was the laying of a 16-in. main in Boston road from the vicinity of Roswell Ave. to Pasco Road, a length of 8,237 ft., and a speed of a little under 200 ft. per day was attained with a gang averaging 12 men; this could probably not have been done without the aid of the machines above mentioned with a gang of less than 60 to 75 men. The cost of the above work was $31,026.

Two thousand seven hundred and forty-seven feet of 16-in. main from Five Mile Pond was also removed with the same gang of men and machines in 20 working days and at an average cost of under $1 per foot, deducting the value of stock salvaged; this pipe was relaid.

A Waterworks Profit and Loss Account.—Springfield, Mass., is one of the few municipalities that keep a profit and loss account of the operations of its waterworks. The following summary of the account for the year ending Nov. 30, 1920, is taken from the annual report of Alfred R. Hathaway, Water Registrar:

OPERATING REVENUES.

Earnings from sales of water to private consumers	$491,628.23	
Less abatements, refunds, etc.	854.81	
		$490,773.42
Earnings from sales of water to the municipality		
Earnings based on prescribed rates for water supplied were $76,[illegible]59.04, but no payments were made therefor, as per city ordinance		......
Water used by municipal water works and included in its operating expenses		64.30
Total operating revenues (water)		$490,837.72

OPERATING EXPENSES.

Source of supply expense	$68,230.05	
Transmission expense	7,126.82	
Distribution expense	69,250.04	
Commercial expense	18,625.76	
General expense	34,676.10	
Undistributed expense	14,608.21	
	$212,516.98	
Depreciation reserve charge	90,172.68	
Total operating expenses		$302,689.66
Operating profit		$188,148.06
Non-operating income (sundry sales, not water)		23,008.25
Gross income		$211,156.31

DEDUCTIONS FROM GROSS INCOME.

Interest on bonded debt (net)	$ 58,169.34
Net income (carried to surplus)	$152,986.97

Specifications for Chemicals Used at Water Purification Plant of Columbus, O.—In his report on the operation of the water purification plant of Columbus, embodied in the annual report of the Division of Water for 1920, Mr. Charles P. Hoover, chemist in charge, summarizes as follows the specifications for the chemicals used at the plant:

Lime.—For any carload of lime containing 88 per cent of water-soluble calcium oxide, the city will pay to the contractor the price per ton stated in the proposal. It is hereby agreed that the city shall pay a bonus of 1½ per cent of the contract price per ton for each 1 per cent by which the water-soluble calcium oxide in carload lots delivered shall exceed 88 per cent, and shall exact a penalty of 1½ per cent of the contract price per ton for each 1 per cent by which the water-soluble calcium oxide in any carload lot delivered shall be less than 88 per cent.

Soda Ash.—The soda ash shall be known as 58 per cent light soda ash, and shall contain not less than 98 per cent of pure sodium carbonate. The material shall be in dry, powdered form, shall contain no large lumps or large crystals, shall be free from chips and other foreign matter, and not more than 0.5 per cent shall be insoluble in cold water.

Bauxite.—The bauxite shall be crushed and dried to contain not over four (4) per cent present moisture, the analysis to be:

Al_2O_3 not less than 54 per cent.

Fe_2O_3 not more than 5 per cent.

Or contractor may state analysis of material which he proposes to furnish; the tri-acid method of analysis to be used.

Bauxite shall be shipped and unsacked in tight box cars; the cars shall be thoroughly cleaned before loading, the door openings shall be boarded up to a suitable height, and all openings by which the material might waste shall be carefully closed.

Sulphuric Acid.—The sulphuric acid shall be 60° B., at 60° F. It is understood and agreed that the seller is privileged to delivery of greater or lesser strength than 60° B. For any excess or deficiency in such acid above or below 60° B., a proportionate increase or reduction shall be made in the price per ton, according to the percentage of 60° acid contained in such acid of higher or lower degree, as set forth in the table of the Manufacturing Chemists' Association of the United States.

Chloride of Lime.—The chloride of lime shall be packed in sheet iron drums, 700 or 800 lbs. per drum, and shall contain not less than 35 per cent available chloride.

A Comparison of Stream Flow at Two Separate Stations

In the study of the flow of a stream at a certain station, more often that not, it happens that any available gagings have been made at some point other than the one under consideration. Some method of comparison of the flow at the desired station with the known flow at the other station is of considerable value, especially if the records at the latter are of long duration.

A comparison of the flow in the Kern River in California at two points 75 miles apart has been made covering a 7-year period. The results are contained in a paper prepared for the Transactions American Society of Civil Engineers by H. W. Dennis. The following data from the paper bring out some very interesting relations:

The Kern River is a typical Southern California stream in the following respects: It originates in the high altitudes where the precipitation during the winter months is principally retained in the form of snow. Its drainage area is made up largely of mountainous country wherein the natural rock is provided with earth covering to a comparatively small depth, and for many large areas there is no cover whatever. The slope of its river bed is fairly uniform from the mountains to the head of the debris cone, below which point the slope is materially less, the stream meanders to some extent, and, comparatively close to the mouth of the canyon, the water is diverted for irrigation purposes.

The first diversion of any large quantity of water on the Kern River occurs at a point a few miles below the mouth of the canyon, and numerous canals of great capacity are led away from the river until, during periods of comparatively low flow, the entire discharge of the stream has been diverted. The waters of the river were appropriated for irrigation purposes, many years ago, under the California laws. An adjudication of the rights of the various owners was made in 1888. In 1894 there was established, a short distance above the first of these large diversions, a gaging station known as the "First Point of Measurement," and at this point records of the daily flow of the Kern River have been kept continuously since that date with the exception of approximately eight months, namely, from July 1, 1907, to March 1, 1908. These records at the "First Point of Measurement" have been kept with great accuracy, in spite of the fact that the stream bed has a bottom of shifting sand.

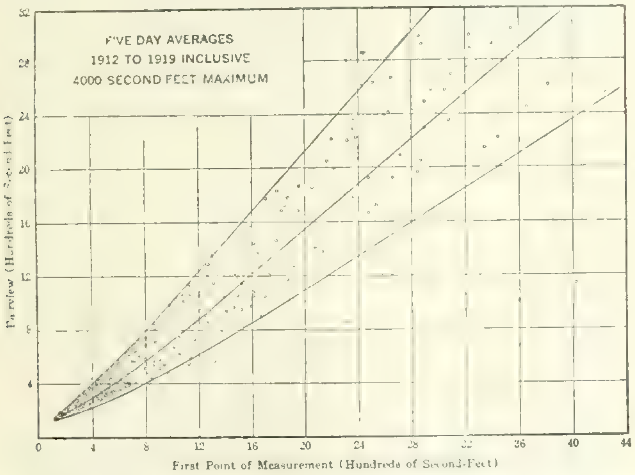


Fig. 1—Five-Day Averages, 1912 to 1919, Inclusive, 4,000 Second Feet Maximum.

About 75 miles above the "First Point of Measurement," the Southern California Edison Co. is now completing a hydro-electric generating station. There were little data as to the flow of the Kern River at the point of proposed diversion, except an occasional measurement of the stream flow. Gagings were started at this point at the beginning of 1912 and have been taken continuously since that date. Initial comparisons of the flow of the river at the two points were made, and as further data were secured the method herein described was developed.

Between the point of proposed diversion on the north fork of the Kern River, and the station known as "First Point of Measurement," the north fork and the south fork of the river join to make the main stream. It is a matter of ob- arated and plotted the results by months. This method will servation that during the period of comparatively low flow in the river very little water is contributed by the south fork.

There are other streams and stream beds entering the river at various intervals, but during the period of low flow in the main river most of these small tributaries are entirely dry.

Determination of Relation of Flow at the Two Stations.—In determining the relation of flow between the "First Point of Measurement" and Fairview, the fundamental assumption has been made that there is a lag of 24 hours between the two points. In making comparison, the discharges for each day have been combined into groups of four, five or six observations, by dividing each month, in general, into six separate groups. In assembling these observations, the five highest observations at "First Point of Measurement" during any one month have been combined with the observations of the corresponding days at Fairview, and so on, assembling according to numerical sequence. In plotting up the data, the discharges at one point have been plotted as abscissas and the discharges at the other point as crdinates. This is not an uncommon method, but the writer has sep- allow for variations in the river characteristics during the rainy and dry seasons. Figure 1 shows all of the points plotted regardless of season. Separating the points in each month a series of curve results as shown in Fig. 2 which are curves actually determined from points on each separate month.

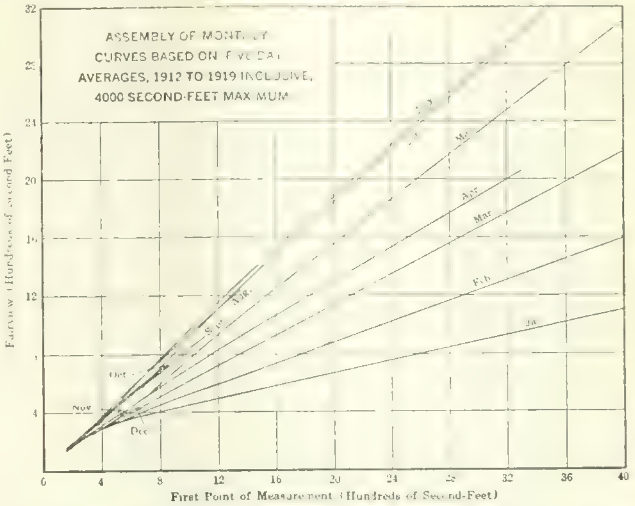


Fig. 2—Assembly of Monthly Curves Based on 5-Day Averages, 1912 to 1919, Inclusive, 4,000 Second Feet Maximum.

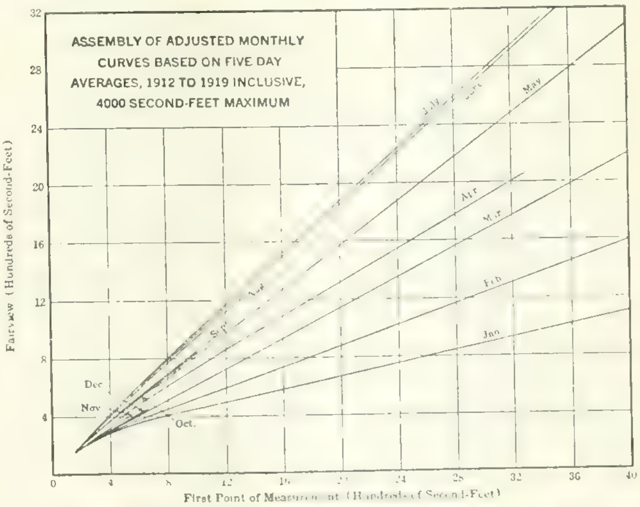


Fig. 3—Assembly of Adjusted Monthly Curves Based on 5-Day Averages, 1912 to 1919, Inclusive, 4,000 Second Feet Maximum.

It is obvious, of course, that the division of these records into monthly periods and the preparation of separate curves for each month has been a matter of convenience only. The river does not know January from February, and it seems proper that all the curves should be similar in shape.

It will be noted on these diagrams that the curve for

M[illegible] the curves for Jan[illegible] February, that the curve for May would apparently, if produced, cross the curve for April, and that the curve for June is quite different in direction from the curve for July. If it is true that the characteristics of the watershed change gradually from month to month, then it follows that the monthly curves should be similar in shape, and the variations to which reference has just been made would not occur if more observations were extended over a longer time. Figure 3 shows the curves by months adjusted to conform to the assumption that the curves should move gradually from one general slope to another. It will be noted particularly that the curves change in definite order in accordance with the sequence of the months themselves.

Applications of the Various Methods.—In order to show the practical application of the method of using monthly curves in comparison with a single curve through the general diagram, Fig. 1, Fig. 4 has been prepared, which shows the hydrograph of the flow of Kern River at Fairview for 1917. This diagram shows: First, the actual flow of the river; second, the flow as computed from the unadjusted monthly curves (Curve A); third, the flow as computed from the adjusted monthly curves (Curve B); and, fourth, the flow as computed from the single curve which was drawn through the general diagram (Curve C).

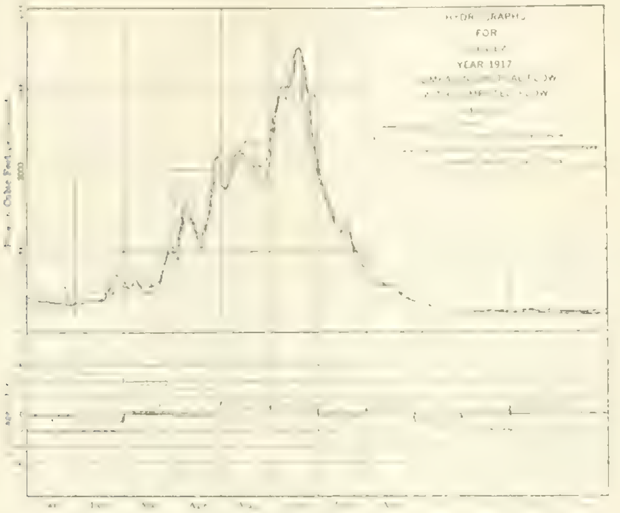


Fig. 4—Hydrographs for Fairview, Year 1917, Comparing Actual Flow With Computed Flow.

The computed curves are based on the actual observed flow of the river at "First Point of Measurement." Certain lines are also shown on Fig. 4, indicating the percentage of error by which the computed flow varies from the actual flow. The hydrographs are based on averages of five consecutive days, dividing each month into six periods, and the curves showing percentages of error take the average of each curve for each month. Table I shows the percentage of error for each month and for the total of the year for each of the three computed curves.

It will be noted that the maximum error based on the entire discharge for any one month from the unadjusted monthly curves is 7.9 per cent, which occurred in December, and that there are only three other months during which the error reaches approximately 5 per cent. It will be noted further that the greatest error of any one month under the adjusted monthly curves is 11.5 per cent, which occurs for December, that there are two other months where the error is 10.4 per cent, and that the errors for the other months are less than 7½ per cent.

TABLE I—PERCENTAGE OF ERROR IN CURVES COMPARING COMPUTED FLOW WITH ACTUAL FLOW, 1917.

Month.	Curve A. +	Curve A. —	[illegible] +	[illegible] —	Curve C. +	Curve C. —
January		0.006		0.104	0.280	..
February		.....		0.104	[illegible]	..
March	0.003	...	0.013		[illegible]	
April		0.009			0.159	..
May	0.030	.....	0.072			....
June	0.051	.....				0.092
July		0.010				0.221
August	[illegible]	..				0.177
September		0.048		0.033		0.173
October		0.012	[illegible]			[illegible]
November	[illegible]				0.017	
December	0.079		[illegible]		0.091	
Total	+0.018		+0.023		+0.003	

Considering the application of the single curve for the entire year, it will be noted that there is only one month where the error is less than 5 per cent; that there are only four other months where the error is less than 10 per cent, and that for the remaining seven months the error is in excess of 15 per cent. It will be noted particularly that the results for the single curve over the entire year substantiate the conclusion that the use of such a curve gives results that are too high during conditions of low flow and too low under conditions of high flow where the river is supported by melting snow.

Considering the total for the entire year, it will be observed that any of the three methods gives for this particular year a result for the total run-off which is less than 2½ per cent in error, and that the single curve for the entire year gives a result which is less than 0.5 per cent in error.

The records at both these stations are based on current-meter observations, for which the error in any individual observation may be as much as 5 per cent. It is probable that these errors would be compensating, so that the total discharge for any given period would be expected to be materially less than 5 per cent in error from the actual amount.

Rainfall and Run-off in the Miami Valley, Ohio

The Miami Conservancy District of Ohio has just issued another one in its series of technical reports, entitled, "Rainfall and Run-off in the Miami Valley," by Ivan E. Houk, District Hydrographer. This report is Part VIII in the series and presents the results of rainfall and run-off investigations carried on in connection with the Miami flood control project.

At the time of the March, 1913, flood there were only a few gaging stations in the Miami Valley and one of the first things accomplished by the engineers for the district after a working plan had been adopted was to place numerous gaging stations throughout the district for the purpose of studying the laws affecting rainfall and run-off. As a practical aid to this study, a number of small experimental plats were established at Moraine Park, about 5 miles south of Dayton, where rainfall and surface run-off could be measured on varying slopes and with varying soil conditions, as well as the rapidity and depth of soil saturation caused by different rains. After about 4½ years of records had been secured, experiments were undertaken, using garden sprinkling cans to reproduce rainfall effects, in an effort to develop a method by which rainfall and run-off relations could be determined for a given watershed without waiting for the natural rainfall.

The results of these experiments are taken up in detail in the report and some of the important results summarized as follows:

Variations in surface slope are of much less importance as affecting run-off than are variations in vegetable cover.

Rain during the summer months seldom percolates to such depths that it is not raised again by capillarity or by root action and evaporated or transpired back into the atmosphere.

From the sprinkling experiments, it was determined that the rate of percolation, when the surface soil is saturated, increases as the rate of rainfall increases, the variation being according to a straight line equation and the rate of increase being proportionally greater for loose loamy soils than for heavy clay soils.

From the studies of annual run-off, the results show:

That annual run-off is much more variable that either annual rainfall or annual evaporation.

The report may be obtained from The Miami Conservancy District, Dayton, O., for 75 cts.

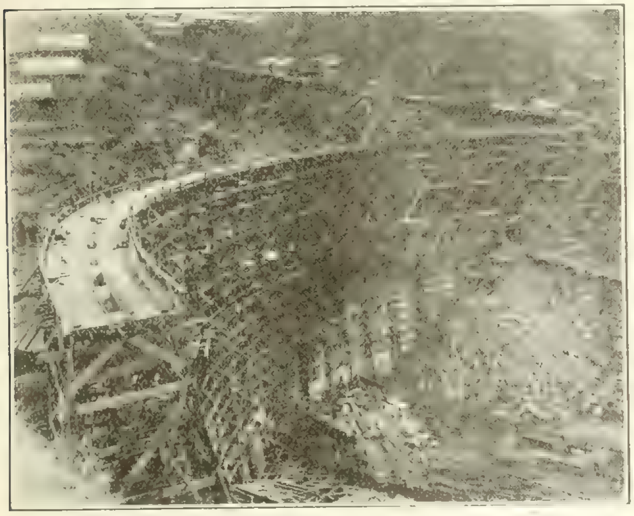
U. S. Supreme Court Decides Passaic Valley Sewerage Case.

The U. S. Supreme Court has refused the application of the state of New York for an injunction to restrain the state of New Jersey and the Passaic Valley Sewerage Commission from building a sewer which will discharge 360,000,000 gal. of sewage daily into the Upper Bay of New York Harbor. The decision ends a legal fight which was begun in 1908. The suit has cost New York over $152,000 to date. Incidental to it, the testimony taken reached 2,500,000 words and 265 exhibits were put before the court. The record contains a mass of original chemical and bacteriological data. Its printing cost New York $20,000, there being 12 large volumes of text, maps and diagrams.

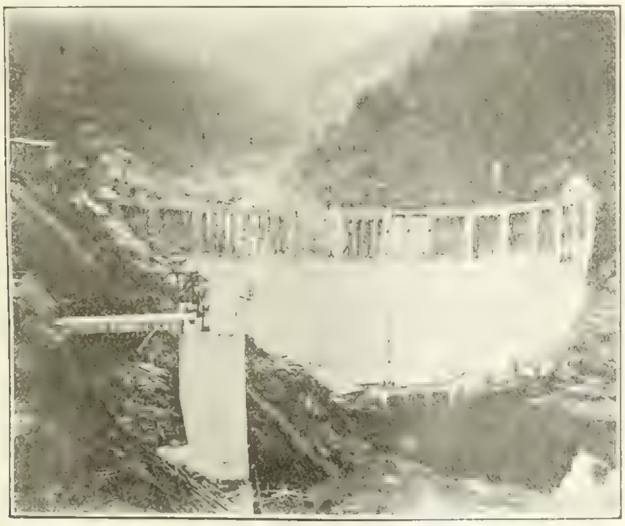
Design and Construction Features of the Kerckhoff Dam

By B. F. JAKOBSEN,
Designing Engineer, San Joaquin Light & Power Corporation, Fresno, Calif.

The Kerckhoff power development of the San Joaquin Light & Power Corporation consists of a diversion dam; 17,000 ft. of unlined pressure tunnel of 320 sq. ft. average area; three penstocks each approximately 930 ft. long, 8 ft. diameter and 5/16 in. thick at the top, and 7 ft. diameter and 11/16 in. thick at the bottom. The elevation of the floor of the tunnel at the lower end is 73 ft. below the normal water surface at the dam. The tunnel is nearly 18 ft. square, on an average, with an arched roof 19 ft. 3 in. radius, and tests with 750 c. f. s. and 1365 c. f. s. give $n = .031$ in Kutter's formula, when the entire tunnel was operated as a pressure tunnel.


Method of Erecting Forms, Scaffolding and Handling Concrete.

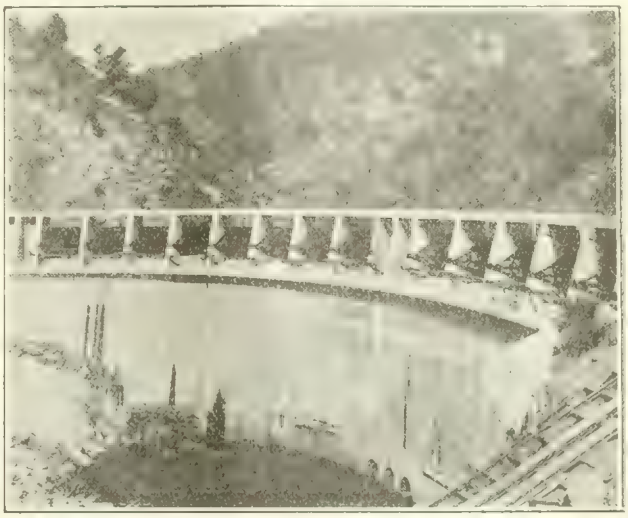
The generating equipment consists of three Allis-Chalmers vertical shaft units of a maximum rated capacity of 15,000 H.P. under a net head of 315 ft. These units have, however, carried 19,400 H.P. under a net head of 340 ft., and have an efficiency about 2 per cent above the guarantee. Vertical shaft units were used because the power house is located in a narrow canyon and the elevation of the river at the power house is subject to a variation of at least 30 ft.


View of Upstream Face of Dam and Intake Structure; Reservoir Empty.

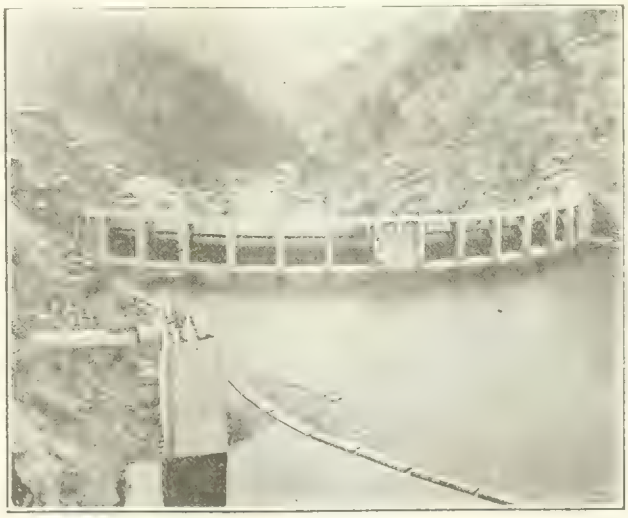
The dam is a diversion dam with about 4,000 acre feet of storage, of which only about 3,000 acre feet are available for the power house, the rest being below the tunnel. This is sufficient to carry full load on the plant for nearly 24 hours with a minimum inflow into the reservoir.

Location of Dam.—The dam is located about 40 miles north and east of Fresno, Calif. The nearest railroad point is Auberry, Calif., and from there a road approximately four miles long was built to the head of an incline, which is 2,000 ft. long and drops 1,000 ft. down to the dam site.

The selection of the site was fixed within narrow limits by the location of the tunnel portal. The site chosen is directly below the tunnel entrance and just above some small falls. The canyon at the site is wide enough to permit the large occasional floods to pass over the top, through 14 Taintor gates, without raising the water surface above normal, which is at elevation 985 ft. This restriction was necessary since the San Joaquin Light & Power Corporation Power House No. 1 is located only one mile above the dam, and normal water surface was selected as high as was possible without interfering with Power House No. 1. Backwater calculations showed that with the water at 985 ft. at the dam and the 14 Taintor gates open, 60,000 c. f. s. can pass over the dam with the water surface at 988 ft. at power house No. 1. No floods, it is believed, will exceed 60,000 c. f. s.


View of Downstream Face of Dam with Taintor Gates in Place.

Flow Data.—Flow records of the San Joaquin River as measured at the company's power house No. 1, check well with the United States Geological Survey data obtained at Friant, some 30 miles farther down the river, except for the very high values, where the U. S. G. S. records show less. This may be due to the flattening of the flood wave through 30 miles of river, though no great accuracy is claimed for the very high values measured by the Power Company. A careful check led the writer to believe that the actual maximum flow at power house No. 1 in January, 1911, was less than the 55,000 c. f. s. measured by the power house crew, and the Taintor gates were therefore dimensioned for a maximum of 60,000 c. f. s.


View of Upstream Face of Dam and Intake Structure; Reservoir Nearly Full.

Selection of Type of Dam.—A multiple arch dam, a gravity dam, and a single arch dam were considered. The multiple arch dam, however, was not thought suitable on account of the heavy overflow. In addition, core borings which were undertaken to prove the site, led to the belief that a multiple arch dam would require a great deal of excavation,—a belief that was afterwards found to be correct. A multiple arch dam would, under the circumstances, have cost more than a single arch dam

A gravity dam would require more than twice as much concrete as a single arch dam and a great deal more excavation, due to the fact that for comparatively narrow canyons the single arch dam is especially advantageous.* In this case the base of the dam is 117 ft. below the high water surface and the top of the dam is 24 ft. below the high water surface, and therefore a gravity dam would have to be at least 80 ft. wide at the base. Against this, the constant angle arch dam, as built, is only 36 ft. at the base. In addition, a gravity dam would have to be provided with a substantial apron in order to protect the foundation from damage due to the occasional heavy floods and the continuous spilling during the high flow months, since only 1,750 c. f. s. are diverted as a maximum.

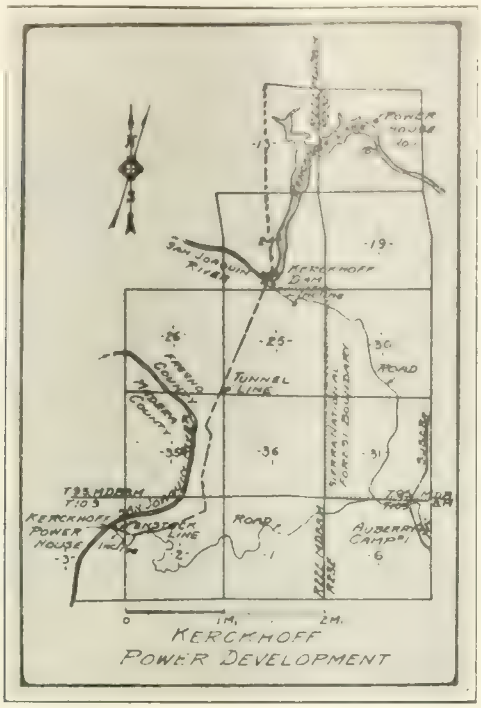


Fig. 1.—General Map of Kerckhoff Power Development.

A constant angle arch dam was finally decided upon and it was built under a license arrangement with the patentee, Mr. L. R. Jorgensen. (U. S. Pat. No. 986718 and No. 1087662.)

It was comparatively easy to inspect the canyon sides and be sure of a first-class foundation for a single arch dam without doing a great deal of investigating, for which there was very little time since the dam had to be completed in the fall of 1919 and the first concrete was poured in the early part of August.

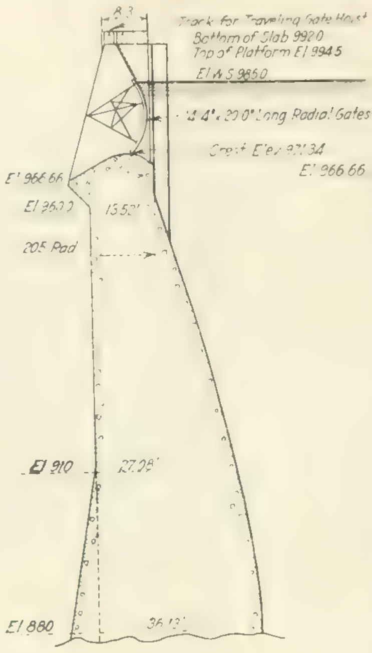


Fig. 2.—Section on Center Line of Dam.

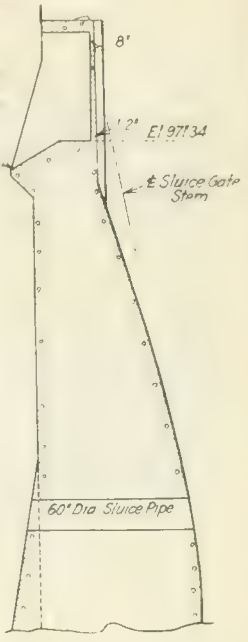


Fig. 3.—Section on Center Line of Sluice Pipe.

General Principle of Constant Angle Arch Dam.—It is assumed in the design of arch dams that the arch stresses, due to the water pressure, is distributed uniformly over the entire section. If t is the thickness of arch in feet, h feet below the water surface, R_u the corresponding upstream radius in feet, and s the resulting arch compression in pounds per square inch due to the water pressure, then

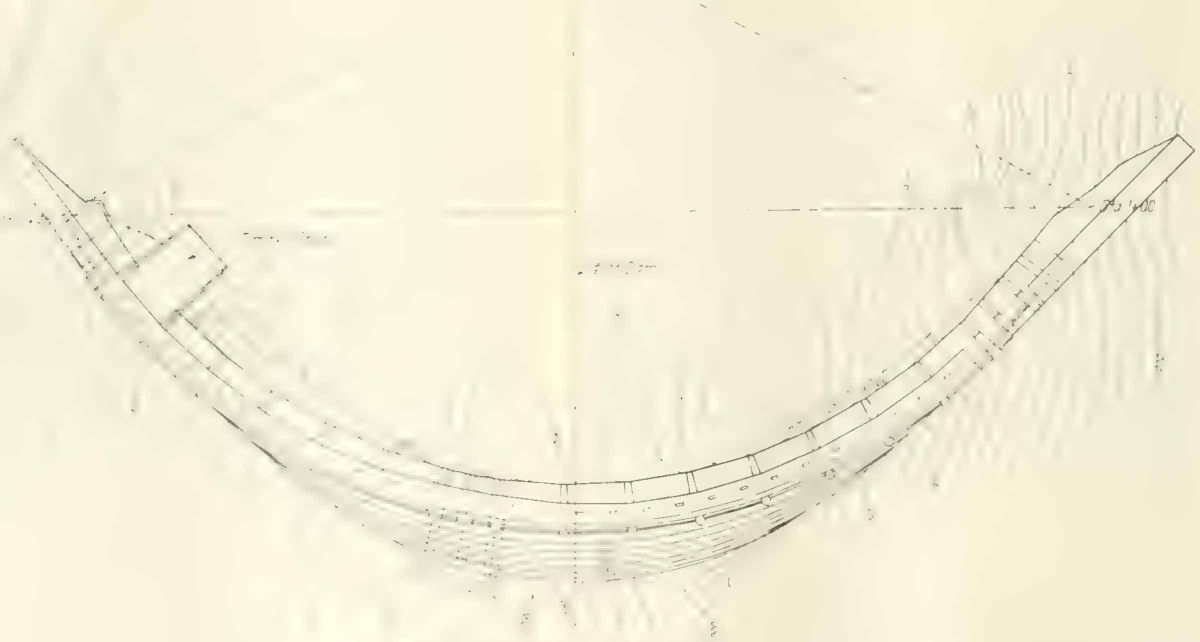


Fig. [illegible]—Plan of Kerckhoff Dam.

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* [illegible] Constant [illegible] [illegible] Engineering and Contracting [illegible]

$$s = .434h \frac{R_u}{t} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

In a paper read before the American Society of Civil Engineers in 1914 Mr. Jorgensen showed that for a central angle of 134° the area of the arch is a minimum. Therefore, if the upstream radius is decreased towards the bottom of the dam in about the same proportion as the site becomes narrower, a saving of concrete is effected.

A single arch dam acts partly as a vertical cantilever (i. e.—as a gravity dam) and partly as a pure arch. When the water pressure deflects the dam downstream, this tends to produce vertical tension in the upstream face. It actually lessens the compression in the upstream face, since all concrete in the upstream face is under compression due to the weight of concrete above; but if the deflection is sufficient, vertical tension in the upstream face is produced. The deflection also produces arch compression in horizontal planes. Compared to a constant radius dam, the constant angle arch dam has a smaller section and smaller radii towards the bottom. The constant angle arch dam, therefore, acts more nearly as a pure arch and less as a gravity dam and it can deflect more without vertical tension being produced in the upstream face. **Under otherwise equal conditions the constant angle arch dam is, therefore, a safer structure than the constant radius arch dam.**

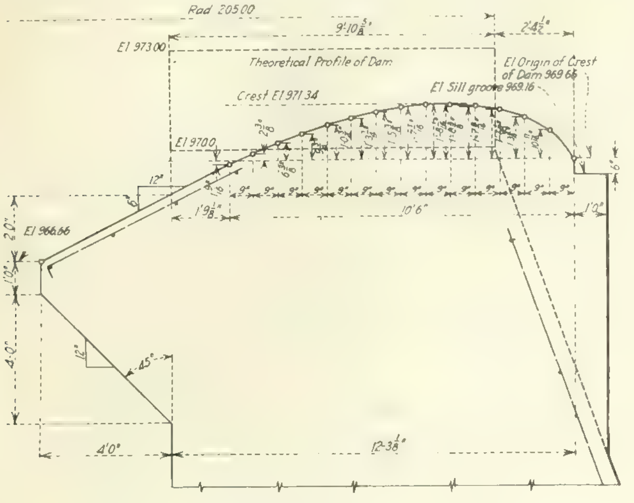

Fig. 5.—Detail of Kerckhoff Dam Crest.

CO-ORDINATES OF CREST.

Point No.	Horizontal distance from origin X.	Rise above elevation 969.66 Y.	Elevation.
1	0"	0"	969.66
2	9"	+0' 10 11/16"	970.55
3	1' 6"	+1' 3⅜"	970.94
4	2' 3"	+1' 6⅛"	971.17
5	3' 0"	+1' 7 9/16"	971.29
6	3' 9"	+1' 8 3/16"	971.34
7	4' 6"	+1' 8 1/16"	971.33
8	5' 3"	+1' 7 1/16"	971.25
9	6' 0"	+1' 5⅜"	971.11
10	6' 9"	+1' 3¼"	970.92
11	7' 6"	+1' 0¾"	970.72
12	8' 3"	+0' 9¾"	970.47
13	9' 0"	+0' 6⅜"	970.19
14	9' 9"	+0' 2⅜"	969.86
15	10' 6"	−0' 1 9/16"	969.53

It is not possible to compute, even approximately, the cantilever and arch deflections due to the fact that for concrete the modulus of elasticity is not constant, the foundations are not unyielding, and especially in large dams not even approximately so. The shear deformation is very considerable, especially near the base of high dams, and the water-soaking of the upstream face produces swelling of the concrete. The effect of shrinkage of the concrete in setting and the variation in temperature still further complicate the calculations.†

Kerckhoff Dam.—A section through one of the Taintor gates is shown in Fig. 2 and a section through one of the 6-ft. diameter sluice gates is shown in Fig. 3. There are three of these sluice gates, located as shown in the plan, Fig. 4. The curtain walls provided above the crest and between the piers assure proper areation of the underside of the nappe. Similar arrangements are made at each end of the dam so that no vacuum can be produced at the downstream face of the dam even during the heaviest floods. The crest of the dam (see Fig. 5) is parabolic and shaped to fit the underside of the water pouring over the dam, and the lip which overhangs the downstream face by 4 ft. throws the water well away from the base. In case of high water there is always a pond of considerable depth at the downstream toe of the dam and this pond acts as a cushion for the falling water. The piers between the Taintor gates are heavily reinforced and some of the steel in the upstream face of the piers was carried well down into the body of the dam so that dangerous tension would not result in the concrete of the upstream face in case the top slab should be damaged, intentionally or unintentionally. This top slab was provided in order to secure complete arch action. The dam was designed for a maximum water surface 24 ft. above the crest of the dam, or at elevation 995 ft., which is 10 ft. higheer than the normal operating water surface. The water could not rise to this height at any flood known on the San Joaquin River except in case a major part of the Taintor gates were left closed, and as this would flood the company's power house No. 1, it is unlikely to happen.

With water at elevation 995 feet, the arch compression as figured by Formula (1) above was selected as 225 lb. per square inch. (See Table I and Fig. 6.) This relatively low stress of 225 lb. per square inch was selected because this is an overflow dam, and, as fars the writer knows, the first of its kind, and because it was intended to build it exclusively from ungraded tunnel muck by eliminating the larger rocks, and finally because it might be subjected to full static head while the concrete was still green. It was found during construction that the requirements of the dam exceeded the supply from the tunnel and it was therefore necessary to add quarried rock to the tunnel muck.

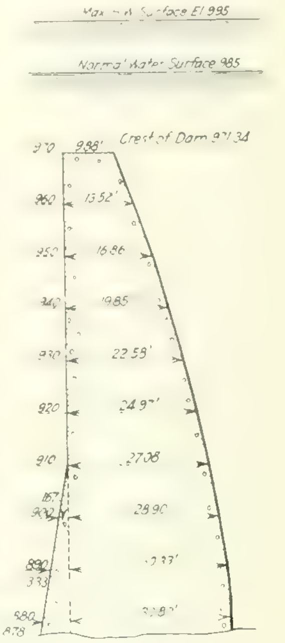

Fig. 6.—Theoretical Section.

As designed, the Kerckhoff constant angle arch dam contains **1,800 cu. yd. less concrete** and required **1,000 cu. yd. less river bottom excavation** than the best constant radius dam which could be designed to fit the site. In addition, it is a **safer structure,** as pointed out above, because tension in the upstream face is less likely to exist, and the dam acts more nearly as a pure arch.

The deepest part of the foundation was on the right bank of the river where a large pocket of boulders and gravel was found. The river was left undisturbed at the left bank and part of the boulders and gravel was removed from the right bank, taking care not to disturb the deposit towards the middle of the stream as this was intended to act as cofferdam. A section immediately adjacent to the gravel bed near the middle of the river was first poured and then the foundation on the right bank was uncovered and concrete poured up to elevation 907 ft. Practically all excavation was done by steamshovel. Three notches were left in this part of the dam and a flume was built on the downstream side to carry the water. The water was then diverted through these

TABLE I—DIMENSIONS OF KERCKHOFF DAM.

s = 225 lb. per sq. in.

Elev.	R_{av}	φ	R_u	t	Triangle	W
970	200.06	122° 10'	205.0	9.88	. .	359.0
960	193.25	125° 10'	200.0	13.52	.	355.0
950	185.87	118° 50'	194.3	16.86	.	334.0
940	177.08	125° 50'	187.0	19.85		333.0
930	168.71	106° 40'	180.0	22.58		288.5
920	160.01	97° 50'	172.5	24.97		260.0
910	151.56	95° 30'	165.1	27.08		244.5
900	143.25	82° 40'	157.7	28.9	1.67	208.0
890	134.54	77° 10'	149.7	30.33	3.33	187.0
880	122.80	66° 50'	138.2	30.80	5.00	140.0
878	...	....	136.2			....

R_u = upstream radius in feet

t = thickness in feet.

$R_{av} = R_u - \frac{t}{2}$

φ = central angle measured on R_{av}

W = canyon width on upstream radius.

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†See the writer's discussion of Mr. Noetzli's paper "Gravity and Arch Action in Curved Dams," American Society of Civil Engineers, Proceedings 1920.

notches and the left bank was [illegible] the foundation put in; also the three 6 ft. diameter sluice gates.

The three notches referred to above, the bottom of which were at elevation 887 ft., were completed into 3 rectangular holes about 11 feet wide by 21 feet high. (The top was pitched as a roof to make the closure easier and prevent air being trapped.) These three holes were not closed until the dam was practically completed, since they were needed, in addition to the three sluice pipes, to take care of minor floods which were to be expected during the fall months.

The first concrete was poured during the first week of August, 1919, and the dam was completed by Christmas. The total yardage in the dam is 23,490 cu. yd. of concrete.

Taintor Gates.—There are fourteen of these, each 20 ft. wide by 14 ft. high, and 11 ft. radius, operated by an electrically driven portable hoist. The general design of these gates was furnished by the manufacturer, the California Corrugated Culvert Co., of Berkeley, Calif., but the design of the belting to secure a tight joint at the bottom and sides and the special bearings necessitated on account of the gates not being in line were made by the Company's engineers.

Since only one bearing was desired at each pier, the offsetting of the gates, due to the curvature of the dam, was accomplished by placing an eccentric brass bushing on each end of the shaft. These brass bushings were secured in their position by a ¾-in. dowel in the end faces of the bearings. The maximum stress in the foundation bolts for the bearings occurs when one gate is closed and the adjacent gate is open. The portable hoist for the Taintor gates was designed by the company's engineers.

Engineers.—The plans and designs were prepared by Messrs. H. Van den Bossche, Oswald Speir, Jr., A. J. Zschokke and Percy B. Dawson, under the writer's direction as Designing Engineer. Mr. R. C. Starr was Construction Engineer in charge of the project, Mr. Edwin H. Warner was Resident Engineer, and Mr. A. G. Wishon was General Manager.

Some Conclusions Regarding Purification of Swimming Pools.—An interesting discussion of the swimming pool in general and the experimental work on two swimming pools at the State University of Iowa, is given by Jack J. Hinman, Jr., Water Bacteriologist and Chemist, Iowa State Board of Health, in the American Physical Education Review for December, 1920. The conclusions reached are: (1) the number of infections due to swimming pools is possibly over estimated, but the fact remains that unless such pools are carefully kept in proper condition, they may be dangerous to the public health; (2) it is important to construct the pool so that it may be kept clean easily. Baths and toilets should be conveniently arranged. (3) strict supervision of the bathers to exclude those suffering from infections and to insure a sufficient degree of cleanliness is essential; (4) refilteration of the pool water is economical and renders the water more attractive. It is not capable of purifying the water satisfactorily under usual conditions without the use of germicides; (5) it is advisable that the purification plant be of sufficient capacity to dilute the contaminated pool water rapidly with freshly purified water. This lowers the concentration of ineffective matter. (6) Chlorine, and copper sulphate, either alone or used with chlorine or calcium hypochlorite have given satisfactory results at the State University of Iowa. Chlorine alone, when administered by apparatus in good working condition gave excellent results; (7) the test of the water of a swimming pool is the character of the water in the pool itself. Although a purified water returning to the pool may be entirely sterile, the purification is not sufficient unless there is enough of the purified water to dilute the contaminating material in the pool water.

Right of Way Gardens.—The Chicago, Rock Island & Pacific R. R. is continuing the practice begun during the war, of leasing to employes right of way gardens. In 1920 the railway leased 1,078 acres for this purpose, the individual lease averaging 2.65 acres. Many of these lessees did not plant gardens exclusively. Some went in for hog and chicken raising, while one employe had a record yield of hay.

Pennsylvania Engineres' License Bill Approved.—Governor Sproul signed the Walker bill providing for the licensing of engineers. The measure regulates the professions of engineering and land surveying and creates a State board for the registering of men in the professions.

Anti-Malaria Work in Mississippi

A general campaign against malaria was undertaken last year in 11 southern states, the work embracing mosquito control in 46 cities. An interesting summary of the results obtained in Mississippi was given by Mr. J. L. Clarke, Sanitary Engineer of the State Board of Health, in the Jan.-Feb.-March Health Bulletin of the Service, from which the matter following is taken.

The work in Mississippi was divided into two units; one in the northwest hill section and the other in the northeast portion of the state.

During January, 1920, surveys were made of 10 towns in the northwest unit to determine; first, the incidence of malaria; and second, the cost of anti-mosquito measures. With this data in hand, those towns which showed a high malaria rate and a relatively low cost of mosquito control were chosen as the most desirable demonstration points.

The ecenomic loss due to malaria, as compared with the cost of control was presented to the city governments. This proposition to reduce malaria sickness, as presented by the State Board of Health, was an attractive one. It showed returns of 400 per cent or better on the principal invested; and, in addition thereto, offered freedom from the mosquito annoyance.

The towns of Batesville, Charleston and Coffeeville accepted the proposition and entered into contract with the State Board of Health. This contract provided for engineering supervision, without cost, plus state aid, but the towns carried a large part of the expense.

Anti-malaria work, as conducted under this program, consists of three essential features; first, drainage and fish control of all permanent waters; second, oiling of all wet weather pools; and, third, elimination of tin cans and other artificial water containers found on home premises.

At Batesville the cost of the work in the town proper was $1,657. In addition to this, work to the value of $1,860 was subscribed by individuals and corporations, to correct drainage conditions near the town which gave rise to mosquito production. This work consised of blasting 1¼ miles of large outlet ditches. The outflow from artesian wells located in town, and flowing through the town in open ditches, was the principal source of malaria mosquito production. Provision has been made to have these wells capped before the next mosquito season starts. It is estimated that the malaria rate was reduced about 70 per cent.

At Charleston, the cost of the work was $1,600. The full ditching program as contemplated was not carried out on account of failure on the city's part to provide their portion of the funds. This necessitated a change in program from ditching to oiling. Some ponds and streams which would have been drained, had to be controlled by oiling; however, satisfactory results were obtained, as the malaria rate was reduced approximately 77 per cent. The funds for oiling operations ran short about Sept. 10, after which time, mosquitoes became plentiful, especially in the unsewered sections of the city. Many complaints were registered, but it seems that the control of all mosquitoes and particularly the malaria species during the months of June, July and August had already effected the desired results as there was no noticeable rise in the normal rate throughout the remainder of the season, even though all control measures had ceased.

At Coffeyville the cost of the work was $1,161. The outstanding feature in the control work was street drainage, or rather, the construction of outlet ditches along the streets in order to drain the interior of each block. The streets had been gradually raised, leaving the block interior saucer shaped. It was necessary to lay tile drain under some of these street ditches in order to get thorough and permanent drainage. The old stream channels outside of town, and within flight range, were provided with outlet ditches, after which treatment they dried up so quickly that very little oil was required during the remainder of the season. The reduction in the malaria rate was 90 per cent.

The program under which this work was started, provides for direct supervision plus state aid during the first year and supervisory aid only to demonstration towns for at least two years thereafter. All towns in this unit have expressed their intention of continuing the work, and arrangements are being made whereby mosquito control will become an essential part of the city government's regular business.

Waterworks Reports and What They Should Contain

Features that should be contained in the reports of municipal waterworks were outlined by Mr. R. E. McDonnell of the Burns & McDonnell Engineering Co., Kansas City, Mo., in a paper presented May 11 at the 10th annual convention of the Southwest Waterworks Association. An abstract of the paper follows:

Why a Report Should Be Made.—A water plant is one of the chief assets of a city; in value it ranks well toward the top of all the city investments, whether owned by the city or company. The success and continued operation of all other industries, factories, etc., are dependent entirely upon the waterworks. The health, growth and prosperity of the city are entirely dependent upon the purity and cleanliness of its water supply. Its customers extend over the entire city, its commodity sold is standardized and is of one quality. When city owned, every citizen of the town is a stockholder and, therefore, a report to the public is due them and the public further has a right to demand a real waterworks report, in keeping with the importance of the utility.

Appearance of Report.—Reports, like people, are often judged by appearances and, therefore, it should have an attractive cover and be of a good quality of paper and printing. Like a girl's skirt, it should be long enough to cover the subject, yet short enough to be interesting. The pictures accompanying a magazine article always produce a desire to read the article and photographs and cuts should be freely used to relieve the monotony in printing and statistics.

What It Should Contain.—A brief historical sketch giving date of purchase or date when built and the present value of the property is always of interest to new customers.

Statistics themselves are rarely read by the layman and these should be converted into graphical diagrams which are understood at a glance.

A concise tabulation of operating costs, annual revenue, fuel costs, increase in number of connections, etc., shown both by figures and graphical charts, are always interesting and these should not cover more than a 10-year period, as old statistics are of little interest or value.

A population curve and water consumption curve are always well worth the making, as it shows what future provision for growth should be made.

A plain statement from health authorities regarding purity of water with percentage of bacteria removed, with cuts or illustrations of bacterial comparison of raw water and treated water, is the best kind of advertising a report can contain, for one must not forget that his business is selling water and the reports help sell the customer. People always like to know how their money is spent and a graphical diagram showing what part of a dollar goes for interest, labor, fuel and operation, is enlightening.

Illustrations showing losses by leaky faucets, bad plumbing and unregulated flush tanks or sewers, are helpful in bringing about reforms. Showing customers how much their own bills could be reduced by eliminating all wastage, is convincing.

The reduced pumpage, reduced fuel or power bills and increased revenue by universal meter system are features that can and should be shown in every waterworks report, for even in this enlightened day, we find a few communities who still sell, or rather give water away, without meter measurement.

The city corporation or individual doesn't exist that can make a success of selling any commodity without measurement of the amount sold. The report should show or account for the loss between water delivered and water sold and if this doesn't show a yearly improvement, something is radically wrong and needs correction.

A waterworks plant is never finished or completed and the needed extensions, betterments and improvements ought always be prominently shown in a report; then there are no shocks or surprises and if bonds are needed there is nothing gained by concealing the fact. Show in the report why the improvements are needed and what advantages and results will be gained by them.

Every report ought to show the cost of delivering water per 1,000 gal., including interest, depreciation, sinking fund reserve, etc. This information is not always known by the superintendent himself and when he figures it out he will, in many towns, find that large users, railroads especially, are getting their water at less than its cost of production. In these days of regulation of rates, one cardinal law acknowledged by all is that the rates of each utility, whether a water plant, light plant, or railroad, should be based on its value and cost of operation. The railroads or other large users are not mercenary institutions with rates made because of their being a special aid or help to a town. Every report should show what the rates should be to earn this interest, depreciation and operating expenses.

Advertising Value of a Report.—A report is of much advertising value to the entire community, so much so that many commercial clubs are joining in the expense of printing and circulating waterworks reports. Every live waterworks superintendent knows the advertising value to himself by getting out a good report. It places him in a favorable light before many other communities where opportunities for advancement are existing.

The educational value is of greatest importance. It acts as an aid in getting bonds for needed improvements, as a basis for argument for equalizing rates or in securing a raise of rates it is of much value.

How Presented.—A report to be of any value must be interesting, for if not interesting it will never be read. The author of the report or some waterworks official should personally present a resume of his report before every civic organization of the town, not omitting the women's clubs.

In Glasgow, Scotland, which city prides itself on being the best governed city in the world, the head of each utility or department is required to give at mass meeting a public accounting of his utility. For example, the water department head gives the workings of the department, its needs, etc. I listened one night to an address by Thos. Melvin, manager of the sewage department, on the subject of "The Cleansing of the Clyde River." He told how the Clyde River had been transformed from a foul sewer-like stream to a beautiful river abounding in fish and lined with houseboats. The lecture, or really his report, was illustrated with slides and was of much interest. These reports, thus presented, kept before the public their needs and caused a keen interest in their own utilities. Extracts from reports are desired by the local papers and should be given them. Send each customer one by the meter reader or hand them out by the window collector. Exchange your reports with the officials of other cities of your state.

The waterworks plant is the chief asset of the city, but the lack of general knowledge concerning it is a fault we can largely correct by getting out and presenting a genuinely interesting report. Whether it pays or not depends on the report and its presentation.

U. S. Public Health Service Making Study of Steam Pollution

An intensive study of stream pollution with special regard to the establishment of a general plan by which any polluted stream in the United States might be purified at a minimum expense has recently been begun by the United States Public Health Service.

The Service has selected for study the Chicago Main Drainage Channel and the Illinois River (which empties into the Mississippi), chiefly because all the primary pollution of this stream originates in Chicago and is accurately ascertainable, both as to amount and character. Analysis taken along the course of the canal and river will determine the degree and nature of the changes that take place in it. Where new pollution is added, its amount and character must be ascertained; and its effect on the old pollution learned. This last is important, for it is quite possible that sundry industrial wastes might neutralize each other or might destroy certain types of organic pollution.

Similar work was done on the Ohio River from 1914 to 1917; and the present study is to check the results obtained there.

The final object is to establish fundamental quantitative relationships between bacteriological and chemical pollution of a stream on the one hand and basic principles, such as population, industrial wastes, stream flow, and prevailing temperature, on the other.

The work in Illinois is in immediate charge of J. K. Hoskins, Associate Sanitary Engineer of the U. S. Public Health Service, and is under the general supervision of Surgeon W. H. Frost.

Proposed Texas Legislation for Licensing Waterworks Operators

[illegible] officials of Texas are [illegible] legislative bill which will, in effect, resolve state supervision of waterworks into advisory supervision. The following account of the proposed legislation is abstracted from a paper presented May 11 by V. M. Ehlers, State Sanitary Engineer, at the 10th annual convention of the Southwest Waterworks Association.

The bill, as proposed, provides for a licensing board consisting of four members. The state health officer, the state sanitary engineer, a professor from a recognized state institution of higher learning, and a waterworks plant operator, the last two to be appointed by the state health officer. Members of the board will qualify with the customary oath of office and receive certificates of appointment.

The duties and powers of the board are to be:

1. To prescribe a standard of proficiency as to the qualifications of those engaged and of those who may engage in the operation of filtration plants.

2. To render free schools or short courses of instruction, each of not more than two weeks' continuous duration, at such convenient points and at such intervals as may be necessary to disseminate pertinent information and facts that will permit operators and attendants and others directly responsible for the distribution of water for human consumption to comply with the provisions and intentions of the act. The state health officer, as president of the board, would be further authorized to dispatch sanitary engineers or technical assistants to such plants furnishing water for drinking or culinary purposes in order to make investigations, sanitary surveys and tests when application is made. The investigations, sanitary surveys, tests, etc., may also be extended to such other water supply plants in the state as, in the wisdom of the board, conditions may warrant.

3. To meet as often as the proper and efficient discharge of its duties may require. Ample notice is to be given in the daily press and otherwise at least two weeks in advance of time and place of each meeting.

4. Three members of the board shall constitute a quorum for the transaction of all its business and performance of all its duties.

5. To elect a president and secretary from the members of the board and to serve for two years or until their successors are elected and qualified.

6. To adopt a common seal.

7. To adopt rules and regulations and by-laws from time to time not inconsistent with the laws of the State or the United States, whereby the performance of all the duties of said board and the practice of operating water or filtration plants shall be regulated.

The legislation would further require that every person charged or desiring to engage in the practice of operating water works or filtration plants, and others responsible for delivering water to the public to be used for human consumption within the State, shall make a written application to the board for a license, accompanied by a license fee of $10. If the board shall find upon examination that the applicant is of good moral character, is possessed of knowledge of the design, operation and supervision of water works plants, has general knowledge for determining the chemical and bacteriological quality of water, has a general knowledge of sanitation and the protection of water supplies, and can show that he has attended a school or schools for such two-year period given under the direction of this board, the board shall issue to said applicant a license as a duly licensed operator. This authorizes him to practice in the capacity of operating water works plants delivering water to the public that may be used for human consumption.

Such licenses are to be signed by a majority of the board and attested by its seal. All persons receiving licenses under the provisions of this law shall have said licenses registered in the county clerk's office in the county within the jurisdiction of which it is proposed to carry on said practice, and shall display said license in a conspicuous place of business of said person so licensed.

Every registered operator who desires to continue the practice of his profession shall annually thereafter, on such date as the board may determine, pay to the secretary of the board a fee of $5 for the renewal of said license. All money received shall be deposited with the State Treasury for this purpose.

It would be unlawful for any person not to register who practices or pretends to practice in capacity of operating water works or filter plants, within the meaning of the law.

Health Administration at U. S. Public Health Service's Model Village

The first annual report on the model health department in the model village which the U. S. Public Health Service has been developing for nearly two years on the 516-acre Government reservation at Perryville, Md., shows some interesting facts.

The reservation was used during the war as a site for a huge nitrate plant. The buildings included 200 cottages, two general stores, a model school house, club, firehouse, and theater for the employes. The whole reservation was turned over by Congress to the Public Health Service for a hospital site and for the storage of the vast quantities of medical stores required for the U. S. Public Health Service hospitals.

The Public Health Service promptly transformed a group of cottages into one hospital and set to build another, the whole now accommodating 430 patients. Not including the somewhat variable hospital quota the reservation now has a population of 839 persons, about equally male and female, with many children and few aged.

The birth rate on the reservation was 39.33 per thousand, as against 24.39 in the whole state and 28.78 in the county. The death rate was only 3.67, the excess in children being probably about balanced by the deficiency in aged persons. While this low death rate is partly due to the favorable age constitution of the population, much of the credit belongs to the efficient health administration.

Careful work has kept the record of communicable diseases low. Particularly was this the case with diphtheria, of which an outbreak was reported early in the year by the village outside the reservation, across the railroad track, from which many workmen came daily to the plant. The Schick test showed that one-third of the children in the school were susceptible to the disease; and all of these were promptly immunized by a new method. Three months later a second test showed that only three still remained susceptible.

During the year 30 cases of diptheria occurred in the county and three on the reservation, one of them a new-comer, one a young sister of a boy who was found to be a carrier, and one an adult.

The low prevelence of contageous disease is ascribed directly to close watch and prompt isolation, laboratory diagnosis, and prophylaxis; and indirectly to pasteurized milk, filtered and chlorinated water, school medical supervision and good living conditions, including sewers, screens, and covered garbage cans.

A physical examination of the children showed that 93.5 per cent had physical defects of teeth, tonsils, adenoids, eyes or hearing, this large percentage probably being due to the lack of facilities for remedial correction nearer than Baltimore. Similar percentages are found in the county outside the reservation. Many of these defects have recently been corrected by the parents.

Between November, 1919 and 1920, the percentage of underweight children was reduced from 42.7 to 13.8.

The drinking water, which is drawn from the Susquehanna River, is naturally in bad condition, being contaminated in several highly variable ways. For use on the reservation it is pumped to settling tanks, where the suspended matter is first precipitated by coagulation with aluminum sulphate, after which the water is passed through sand filters. This purification is further supplemented by disinfecting the water with liquid chlorine.

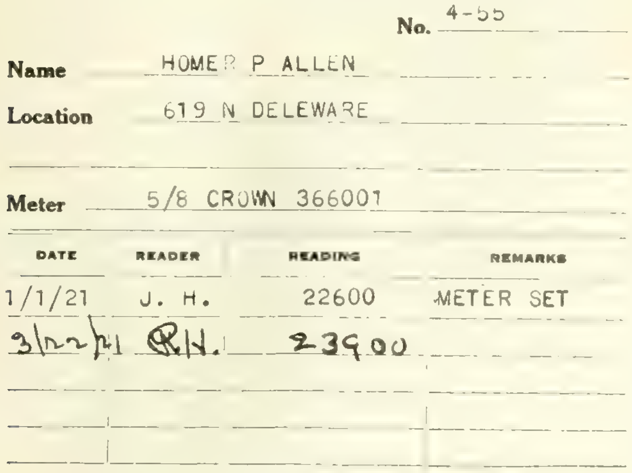
Mosquitoes were practically exterminated by the usual methods. This was essential, both to afford much needed relief, and to prevent malaria being transmitted from soldiers in hospital who had been trained in southern camps and might have become carriers of the malaria germs.

The reservation offers many facilities for research work, particularly in various phases of santitary engineering. Its location suggests it as a school where public health administration can be taught practically to all interested.

How to Get Out Water Bills Promptly

A system of posting and billing water consumers' accounts, that includes some useful "short cuts" is used by the Independence Waterworks Co. of Independence, Mo. The methods were described by Mr. H. A. Gallagher, manager of the company, in a paper presented May 12 at the 10th annual convention of the Southwest Waterworks Association. The notes following are abstracted from Mr. Gallagher's paper:

Whether you bill monthly or quarterly you have all had the experience of having reached a point in the amount of work to be done where there is just a little too much for the present force but not enough to warrant the employment permanently of additional help. No matter what method or system you employ you will always reach such a point as described, but if the amount of work one clerk can do is increased, that increase represents the measure of added efficiency.



		No. 4-55	
Name	HOMER P ALLEN		
Location	619 N DELEWARE		
Meter	5/8 CROWN 366001		
DATE	**READER**	**READING**	**REMARKS**
1/1/21	J. H.	22600	METER SET
3/22/21	R.H.	23900	

Meter Readers Record Sheet (Actual Size 8x4¼ In.)

The meter reader's record sheets are arranged in loose leaf form, in rotation most conveniently corresponding to the street and house number of the route. Each sheet bears a route number, and a number corresponding to the numerical position of the meter upon the route, together with the consumer's name and house number, the size and make of the meter and the attachment or service number.

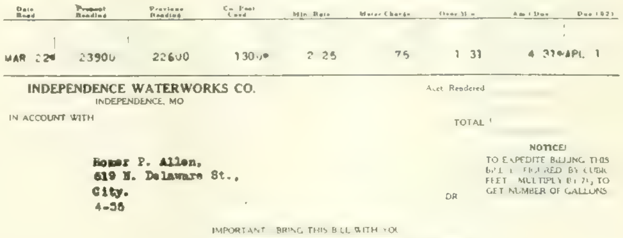
The loose leaves in the customer's ledger are arranged to correspond exactly with the arrangement of the sheets in the meter reader's route book, and bear the same identification numbers. This arrangement of sheets is made at the time contract for service is taken. The account on the ledger is opened under the heading of the street and house number. The consumer's name is entered in the column at the left and any change in the consumer is entered lower in the column and the date of change entered in columns provided for, on and off record. A section of the sheet is ruled for the meter record and another section for sales and charges and credits or refunds. "V"-shaped reference racks for the ledgers are provided so that the various accounts can be as readily referred to as a card index.

The loose leaf ledger binder is so constructed that it can be readily opened up on a "W" posting rack, the slides of which are pitched to such an angle that the ledger sheet to be removed is raised slightly above its neighbor, thus facilitating its removal for placing in the bookkeeping machine. An alignment device on the machine instantly brings the sheet to the proper position and a condensed billing attachment provides for ready alignment of double faced carbon sheets and duplicate bills. The present and previous meter readings, which we have found very satisfactory to enter in round numbers of hundred feet, except of course for final bills, are printed and the difference which is computed by the machine is then entered. This difference is carried forward during the day's operations in an accumulating counter in the machine, showing the total amount entered upon the books as cubic feet of water sold. Reference to a conveniently arranged shart determines the amount of the charge for the sale. This amount is entered on the sheet and any additions thereto are then entered. In this particular case the amount of the minimum rate and the amount of meter rent, if any, both charges being payable in advance, are entered and then from the chart the amount of the sale in excess of the minimum charge, if any, is entered. The machine automatically cross adds this amount and the sum is printed upon the sheet. The duplicate bill is so printed that the marked spaces for the several entries correspond exactly to the spaces for the same entries upon the ledger sheet. A second accumulating counter on the machine carries the total charges forward during the day's operation so that the operator may know at any time the total gallons sold and the total amount charged upon the books for the same, a feature that all superintendents will appreciate when making up their reports.

The operator in charge of the machine is not a professional typist but has acquired a speed that enables him to transfer the statement from the meter reader's route sheet to the ledger, compute the account and make duplicate bills for 500 accounts in an 8-hour day. It is quite possible that an expert typist could exceed this number.

The billheads are addressed by an addressing machine. The stencils are cut in the office and filed in their racks to correspond with the ledger sheets. One copy of the bill is retained in the office and filed in the same order as the account in the ledger. The other copy is mailed to the customer in a window envelope.

The items making up the rate of most water companies or water departments would not require as wide a ledger sheet or bill as with us, and in most cases the usual mailing card or bill with stub attached could be used in preference to the duplicate bill. We at first feared that the wide sheets we required would prove awkward and cumbersome, but they have not proven to be so. Our sheets are ruled to use both sides and will permit of use for several years. We would advise any one adopting the machine method of handling accounts to choose the best of paper with the grain running vertically in the sheet.



Date Read	Present Reading	Previous Reading	Cu. Feet Used	Min. Rate	Meter Charge	Over Min.	Am't Due	Due 1921
MAR 22*	23900	22600	1300*	2 25	75	1 31	4 31*	APL 1

INDEPENDENCE WATERWORKS CO.
INDEPENDENCE, MO
IN ACCOUNT WITH

Acct. Rendered
TOTAL
DR

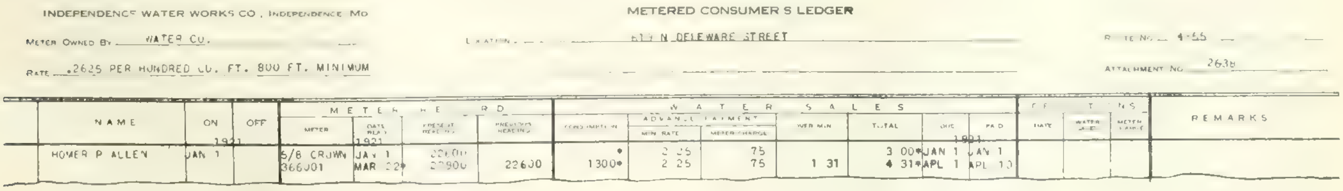
Homer P. Allen,
619 N. Delaware St.,
City.
4-56

NOTICE!
TO EXPEDITE BILLING THIS BILL IS FIGURED BY CUBIC FEET. MULTIPLY BY 7½ TO GET NUMBER OF GALLONS

IMPORTANT: BRING THIS BILL WITH YOU

Consumers' Bill (Actual Size 8½x3½ In.).

At the time this equipment was installed the amount of work to be done had reached a point where additional clerical help was necessary. With the machine the old force has been doing the work and the cost of equipment did not exceed the amount of what a year's salary for a fairly good clerk would have been.



INDEPENDENCE WATER WORKS CO., INDEPENDENCE, MO

METERED CONSUMER'S LEDGER

METER OWNED BY WATER CO.
LOCATION 619 N DELEWARE STREET
ROUTE NO. 4-55
RATE .2625 PER HUNDRED CU. FT. 800 FT. MINIMUM
ATTACHMENT NO. 2638

			METER RECORD				WATER SALES							[illegible]			
NAME	ON	OFF	METER	DATE READ	PRESENT READING	PREVIOUS READING	CONSUMPTION	ADVANCE PAYMENT MIN RATE	ADVANCE PAYMENT METER CHARGE	OVER MIN	TOTAL	DUE	PAID	DATE	WATER [illegible]	METER [illegible]	REMARKS
HOMER P ALLEN	1921 JAN 1		5/8 CROWN 366001	1921 JAN 1 MAR 22*	22600 23900	22600	• 1300*	2 25 2 25	75 75	1 31	3 00* 4 31*	1921 JAN 1 APL 1	JAN 1 APL 10				

Sheet From Loose Leaf Ledger (Actual Size 18x12 In.).

A. A. E. Has 24,480 Members.—On May 1 the American Association of Engineers had 24,480 members, of which 3,771 are students. The association has 188 chapters and 75 clubs.

Final Report on Disposal of Industrial Wastes from Chicago Stockyards

After investigations of the disposal of industrial wastes from the stockyards district covering the last nine years, the Sanitary District of Chicago has just issued its final report which deals principally with the use of the activated sludge process for treating the industrial wastes from the stockyards and packingtown. A preliminary report was issued in 1914 giving the results of earlier experiments, using Imhoff tanks and sprinkling filters. As a result of these earlier investigations, it was decided that this method of treatment, using somewhat lower ratings on sprinkling filters than generally used on domestic sewage, would produce a satisfactory effluent when treating the wastes from the stockyards region. At about this time the activated sludge method of treating sewage came into prominence and experiments with this process were at once commenced. Small scale experiments were at first tried and demonstrated the feasibility of the process in treating these wastes. These were followed by experiments on a suitable working basis.

The Stockyards' Waste Disposal Problem.—Some idea of the problem confronting the Sanitary District of Chicago in attempting to take care of the wastes originating in the stockyards district may be gained by the statement that in 1920 the total population of the Sanitary District was around 2,976,443, of which 2,757,575 drain into the main channel, while studies show that the stockyards wastes are equivalent to about 1,000,000 people. Adequate and sufficient treatment of these wastes before they enter the main channel will thus considerably lessen the load to be taken care of.

The crude sewage is strong compared with a domestic sewage. It was strongest in 1917. For the day sewage, the suspended solids range from 281 to 506 p.p.m. on monthly averages, the oxygen consumed from 150 to 269 p.p.m., the fats from 80 to 191 p.p.m. and the biochemical oxygen consumption from 834 to 1,477 p.p.m. For the night sewage, the suspended solids range from 73 to 313 p.p.m. on monthly averages, and the fats from 12 to 134 p.p.m. Most of the nitrogen present is in organic form, the ammonia nitrogen being very low.

The temperature of the crude sewage is higher than in domestic sewage, the effluent averaging 55 to 60° F. in the winter months.

Methods of Operation in Activated Sludge Experiments.—The large scale activated sludge experiments were divided into three methods of operation: (1) Operation on a continuous flow bases with the sludge returned directly from the settling tanks to the aeration tanks; (2) operation on a continuous flow basis but with the sludge re-aerated and resettled after removal from the settling tank before being returned to be mixed with the incoming sewage; (3) operation during winter conditions on a continuous flow bases, but without re-aeration of the sludge before return to the aeration tank.

First Period. Continuous Flow. Without Re-aeration. July 1, 1916, to March 26, 1917. 15 Runs.—From July 1 to Oct. 22, effluents were secured with a relative stability of 52 to 90 on the run averages. The periods of aeration ranged from 8.9 to 13.2 hours, with settling periods of 1.6 to 2.7 hours. The air used was from 3.27 to 4.41 cu. ft. of free air per gallon with a distribution from 0.25 to 0.31 cu. ft. per square foot on run averages. The highest stabilities occurred with the longest aeration period, the lowest with the shortest. The results showed, however, that during the warmer weather an effluent with a stability of over 50 could be secured with about 9 hours' aeration and 3.5 cu. ft. of air per gallon of sewage, corresponding to a rate of 0.34 cu. ft. per square foot per minute.

From Oct. 23, 1916, to March 26, 1917, effluents were secured with a relative stability of 10 to 38, on the run averages. The period of aeration ranged from 6.9 to 10.9 hours with settling periods of 1.1 to 2.2 hours. The air used was from 3.17 to 6.52 cu. ft. of free air per gallon with a distribution from 0.24 to 0.59 cu. ft. per minute per square foot on run averages. The results showed, however, that during the colder weather an effluent with a stability from 10 to 38 could be secured with about 9 hours' aeration and 4 to 5 cu. ft. of free air per gallon of sewage. The increase of air to 6.5 cu. ft. per gallon did not produce a stability higher than 27.

When four aeration units were operating, the stabilities taken from the effluents at the outlet of the second and third indicate that the function of the last unit is largely to condition the sludge.

Second Period. Continuous Flow Re-aeration. March 27 to Nov. 14, 1917. 10 Runs.—During this period the sludge was re-aerated and settled, before return to the aeration tank. Air was applied uniformly throughout 24 hours but increased daily from Monday to Saturday. Re-aeration of the sludge effected a large reduction in volume of sludge returned. More sewage was treated in three aeration tanks than previously in four. Average aeration periods were around 5.3 hours in the sewage tanks, and 3.8 hours in the sludge reaeration tank, the weighted average being equivalent to a 6.6 hours' period. The average settling period was 1.8 hour in the primary, 1.6 hour in the resettling tank, the weighted average being equivalent to a 1.7 hour period. The air consumption was approximately 2.5 cu. ft. per gallon of sewage and 2.9 cu. ft. per gallon of re-aerated effluent, a weighted total of 3.5 cu. ft. per gallon of sewage treated. The stabilities obtained, however, were low from the main settling tank, running from 32 to 94, and somewhat higher from the resettling tank running from 38 to 97, the averages for the combined effluent running from 38 to 95. The results on the day flow are lower.

Third Period. Continuous Flow. Without Re-aeration. Nov. 16, 1917, to Feb. 12, 1918. 4 Runs.—During this period, the sludge was returned directly from the main settling tank, without re-aeration or resettling. An average of 4.3 cu. ft. of air per gallon of sewage was used, with an aeration period of 8 hours. The settling period was 0.97 hour in the inclined tank. The stabilities averaged from 41 to 71 per cent.

Sludge Ratio.—The sludge return on run averages, ranged from 48 to 79 per cent, being lowest in the warmer months. The normal was about 60 per cent. An average of 30 per cent seems to be required for the sludge per cent in the tanks. This varied from 19 to 48 per cent. In winter, a somewhat higher percent is required than in summer. But for clarification only, the amount may be reduced, averaging from 20 to 28 per cent.

Results, Summer and Winter.—In the warm weather, the organic nitrogen is well reduced. The ammonia nitrogen is reduced in lessening amount as the weather cools. The nitrate formation was strong. In cold weather the organic nitrogen was reduced, but in slightly lower amount. The ammonia nitrogen increased markedly, as opposed to a decrease in warm weather. The nitrate formation was markedly decreased.

Comparison of Aeration vs. Re-aeration.—Comparison of summer results indicates a saving of approximately 27 per cent of aeration tank volume with re-aeration and resettling of the sludge. But 31 per cent more settling tank capacity is required. Consequently a net saving of 20 per cent of tank volume seems probable. A slight saving in air consumption, approximately 10 per cent, also appears possible with re aeration.

The effluents produced are fairly comparable, though the "aeration" effluent is in general somewhat better.

Settling and Concentrating Activated Sludge.—The rate of subsidence depends on the state of activation, physical appearance, moisture content and temperature. In general but little additional concentration was gained by settling more than 2 hours. The concentration occurred much faster in the shallower tank.

The position of the settling vessel also had an influence in cylinder and can experiments, probably in large part because of the increase in effective settling area. Inclinations of less than 45° with the horizontal were not effective.

This principle can be utilized, if desirable, in settling tank construction on a small scale. The results indicate a rate of settling for a 60° inclination of 950 to 1,400 gal. per square foot tank area per 24 hours, compared with the Dortmund type, horizontal flow type or combined vertical and horizontal flow type of 500 to 680 gal. per square foot per 24 hours.

Analyses of Packingtown Sludge.—Typical activated sludge from Packingtown is brown in color, settling quickly, and leaving a distinct line of demarcation. The moisture content in the aeration tanks, after 1 hour settling, and in the settling tanks practically runs over 99 per cent water.

Typical analyses are as follows:

Sludge.	Sp. gr.	Per cent moist.	Calculated to dry weight per cent Nitrogen.	Volatile.	Fixed.	Ether Sol.
Activated	1.004	99.15	4.17	62.6	37.4	6.0
Imhoff	1.02	91.5	2.72	65.	35.	6.6
DORTMUND TANKS.						
Tank D.........	1.02	91.7	2.88	76.	24.	8.6
Tank C.........	1.02	90.6	2.65	72.	28.	8.1
Acid treatment.	1.02	92.5	3.07	74.	26.	18.8

These typical analyses show that activated sludge is more liquid, higher in nitrogen and lower in fat, on Packingtown sewage, than other sludges.

Relation of Sludge to Suspended Matter.—In determining the dry weight of the sludge, special precautions were taken to eliminate error from solids in solution.

The results in the various periods may be summarized as follows:

	Per million gallons.		
	Pounds removed dry-basis.		Sludge percentage suspended matter.
Period.	Sludge.	Suspended matter.	
1916, Sept. 17 to 1917, Mar. 26	2,680	2,820	95
1917, Mar. 27 to Nov. 14.....	1,924	2,280	84

Dewatering Sludge.—The experiments tried at the Stock yards Testing Station included air drying on sand beds, lagooning, concentration, and filter pressing.

On prepared sand beds, activated sludge dried much more slowly than Imhoff sludge.

Lagooning was unsuccessful. The sludge settled to the bottom, the water remained at top. Concentration was effected only by evaporation. Considerable odor developed.

Sludge was pressed successfully without the use of lime in a standard type of plate press.

Tests were made with a plate press of the center feed type, containing 12 corrugated plates, each of 225 sq. in. filtering area, having 11 chambers. The sludge was fed by an ejector. For the best results, the air pressure was built up in pounds per square inch as follows:

At start, 15; at ½ hour, 60; at 1 hour, 100; at 2 hours, 140.

The time of pressing varied from 2 to 5 hours, but was materially shortened by providing a sludge well activated, with the characteristic physical appearance.

The first 20 tests were made with a ⅞-in. cake. Radial ribs were then added, which improved the hardness of the cake. Thicker cakes were tried from 1 to 1⅜ in. The thicker cakes were less firm, the thickest being the softest.

The use of acid (sulphuric acid or acid cake) in amount sufficient to neutralize the alkalinity of the sludge, improves the yield of cake, prevents decomposition of the sludge, reduces clogging of filter cloths, increases the nitrogen and fat content of the sludge.

The sludge before pressing ranged from 97.9 per cent moisture upward. The cake varied in moisture content, from 78.5 to 89 per cent, without the radial ribs, and from 74.2 to 80.6 with the ribs. The more concentrated the sludge (within the limits investigated) the shorter the time of pressing and the better the results.

Acidification increased the yield of a pressing in one case 38.5 per cent, and in another 11.7 per cent, but in the latter case a drier sludge was produced in half the time required for non-acidfied sludge. The same result was noted with dye-works acid waste or with nitre cake, used in place of sulphuric acid.

Sludge analyses made during the press tests showed a higher proportion of organic nitrogen than the sludge previously noted. The nitrogen content varied from 3.70 to 6.80 per cent, dry basis. Acidification increased the amount of nitrogen from 0.72 to 2.88 per cent. On an average of 10 analyses each, of sludge with and of sludge without acidification, the acidified cake contained 5.85 per cent and the non-acidified cake 5.08 per cent organic nitrogen. The ether soluble was also increased from 3.67 to 5.85 per cent.

Cotton duck cloths gave as satisfactory results as linen. For the 52 tests, two complete sets of cotton duck cloths were used.

The addition of ribs made a sectional plate, forming the cake in smaller sections, and increasing the relative drainage area as compared to cake area. The improvement was pronounced on a ⅞-in. cake basis, the cake yield being practically doubled.

Acidification with sulphuric acid was helpful in reducing the moisture content of the sludge and conditioning it so that it would release its moisture more readily. This effect was more clearly demonstrated by the filter pressing, where the capacity of a press was practically doubled.

Settling Tanks.—In hopper bottom tanks, bottom slopes of 30° with the horizontal were found insufficient. A 45° slope was not entirely satisfactory. A slope of 1.8 vertical to 1 horizontal (61°) proved satisfactory. With hopper bottomed vertical flow tanks a period of about 1.5 hours was used. The best results were obtained with the inclined baffle tanks.

Filtros Plates.—The first lot of plates proved soft. They were replaced by satisfactory plates by the makers. The tests showed the need of supporting each plate on 4 sides in a sturdy box. There was a marked increase in the air pressure, equivalent to 3.2 ft., during the period of April 23 to Nov. 14, 1917. The clogging was largely due to rust.

Effect of Screen on Activated Sludge.—The use of the fine screen seemed advisable to remove much comparatively inert material which is slow to oxidize. The runs made with a screen did not appear to differ greatly in character of effluent from those without. The coarser material, however, deposited in various undesirable places. When the screen was not used, additional air was required to keep coarser material in suspension.

Oxygen Required. Comparison of the total oxygen required for the oxidation of the sewage showed a demand of 990 p.p.m. at Center Ave. on the strong day sewage.

Fine screening (20 to 30 mesh), even though removing 25 per cent of the suspended matter, had small effect on the stability of the liquid, reducing the oxygen demand from 0 to 8 per cent.

Settling in the Imhoff tank made a reduction on the day crude sewage, in the oxygen requirement, between 23 and 32 per cent.

Settling in the Imhoff tank, followed by the sprinkling filter, made a total reduction on the day crude sewage in the oxygen requirement, of 87 per cent.

The activated sludge process made a total average reduction on the day crude sewage in the oxygen requirement to 42 p.p.m. or a reduction of about 96 per cent.

The acid treatment of the sewage made a total reduction on the crude sewage in the oxygen requirement of about 40 per cent.

The report is issued by the Sanitary District of Chicago of which Albert W. Dilling is Chief Engineer. Langdon Pearse, Sanitary Engineer, had charge of the experiments and the preparation of the report. Dr. Arthur Lederer, former Chemist for the District, carried on the investigations into the chemical and biochemical field.

Underground Water in Western Kansas.—In the course of its work of making a geologic atlas of the United States the U. S. Geological Survey has just published the Syracuse-Lakin folio (No. 212), containing a description and maps of a part of southwestern Kansas, most of it is in Stanton, Grant, Hamilton, and Kearny counties along and near the valley of Arkansas River. The rainfall in this region averages slightly less than 20 in. a year, so there is urgent need of water for irrigation and for domestic use, as well as for stock raising, which is the principal industry. The folio shows that large quantities of water can be obtained by means of wells drilled to moderate depths at places in the lowlands, but this water has not yet been extensively used for irrigation. The folio, which is the work of N. H. Darton, of the Geological Survey, contains topographic and geologic maps, sections showing the relations of the rocks, and hydrologic maps showing the distribution of underground water. It is sold for 25 ct. and can be obtained from the Director of the U. S. Geological Survey, Washington, D. C.

The Future of the Consulting Engineer.—In an address last April before the Los Angeles Section of the American Society of Civil Engineers, Mr. George W. Fuller, Consulting Engineer, New York City, expressed some rather pessimistic views as to the outlook for consulting engineers.

Mr. Fuller stated that frankly he did not see great promise in the future for the consulting engineer. His field has been gradually encroached upon by engineers representing financial interests and corporations and the development of engineering activities in other directions. Before the war, he said, there was a number of consulting engineers in New York City whose business amounted to $20,000 to $30,000 a year. During the war they gave their services to the country. Since they have reopened their offices some of them have not had even enough business to pay office rent. Mr. Fuller referred to the thinning of the ranks of consulting engineers in Europe, particularly in France and Germany, where they have practically disappeared.

Methods of Preparing and Handling Wood Pipe River Crossing

By LOUIS D. KEL[illegible]

City Engineer, Raymond, [illegible]

The city of Raymond, Wash., has [illegible] water pipe, river crossings, one in the North Fork and two in the South Fork of the Willapa River. The United States Government is at this time dredging the [illegible] to a depth of 24 ft. below mean lower low water, thus requiring the removing and relaying of all the three river crossings. The first of these, a 12-in. line, has been laid and the others will be when the dredging has been completed.

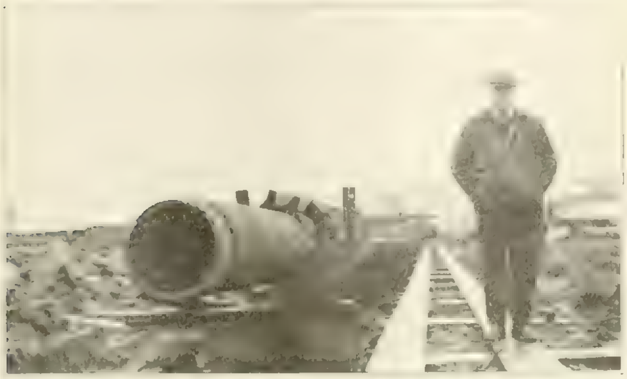


Fig. 1—Pipe in Preparation, Showing Skids, Rails and Covering of Planks and 2x4's.

Kind of Pipe.—The pipe used for this crossing was a 12-in. wire wound wood pipe, with a 1¼-in. shell wound for 125 lb. working pressure, with a 6-in. drive into the collars. Short lengths of pipe were used so as to approach, as nearly as possible, the profile of the river bottom. The length of this crossing was 302 ft.

Pipe Covering and Carriage.—The pipe before being used was dried and painted with two coats of prepared asphaltum. As shown in Fig. 1, the pipe was assembled on skids raised about 2 ft. off the ground so as to afford the workman easy access for the placing of bands around the section when built up.

After the pipe was assembled and driven up to place, 1 by 3-in. fir strips, laid flat, were placed outside the wire banding to fill out even with the outside of the collars on the pipe. On these were placed two layers of 2 by 4-in. fir strips, laid flat, which filled out even with two lines of 60-lb. steel rails placed on opposite sides of the pipe. The steel rails were fastened together with angle bars, thus giving two continuous ties from end to end of the pipe. Three-eighth inch iron bands, held with shoes and spaced 8 in. center to center, were then placed around this section as made up.

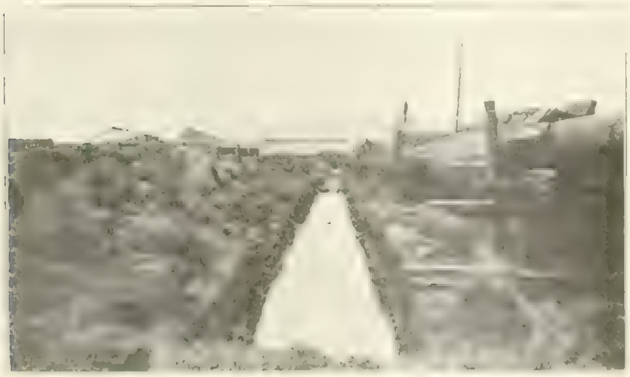


Fig. 2—Pipe in Preparation Beside Launching Ditch.

Special Ditch for Floating Pipe.—As shown in Fig. 2, a ditch was dug parallel with the pipe and connecting with the river, into which the pipe was rolled after the tide had flooded high enough to fill the ditch. The last operation before rolling into the ditch was the plugging of both ends of the pipe with well fitted wooden plugs. The pipe after being rolled into the ditch was floated endwise across the river by means of a pile driver and swung into position as shown in Figure 3. To insure the even settling of the pipe into place, it was loaded with bags of clay placed over it, tied together and distributed evenly throughout the length of the line.

On both the flood and ebb of the tide in these streams there is a strong current, so that it was necessary to wait until slack water at extreme high tide before lowering the pipe into place. After lines had been fastened on each end of the pipe to hold it in place, the end plugs were knocked out, and the pipe sunk into the position desired. After allowing a few weeks for settlement of the pipe, to eliminate as much as possible the pulling of connections at the ends on the banks, the pipe was connected up to the shore lines.

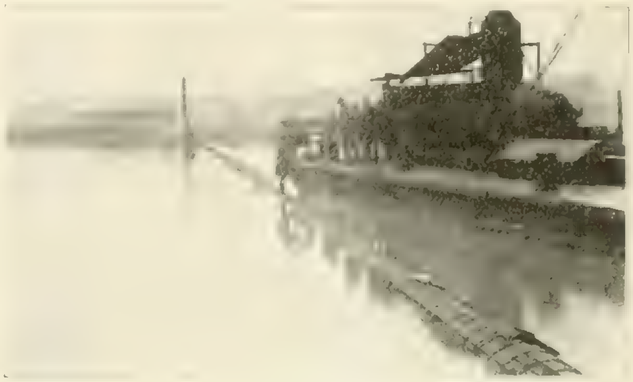


Fig. 3—Encased Pipe Floated Into Position Across River.

This work was done by the Water Department of the city of Raymond, Vern English, Water Superintendent, and the writer as City Engineer.

The Texas State Board of Health School for Filter Plant Operators

Five years of visiting water-plants convinced the small staff of engineers of the Texas State Board of Health that slow progress was being made in the way of securing adequate treatment works and competent operation of all of the plant in existence. Accordingly a school of instruction of two weeks' duration was given for plant operators. This first short course was such a success that the school system has been made a part of the program. The following details regarding the work at the school were given by Mr. V. M. Ehlers, state sanitary engineer, in a paper presented May 11 at the 10th annual convention of the Southwest Waterworks Association. The work given at these schools consists in taking the visting operators to a plant and there explaining to them, in detail, the working parts and functions of a treatment works. Experts on design, operation, filtration, chlorination, underground geology of water, etc., are brought to this school to lecture. The operators in attendance at the same time are given instructions in interpreting chemical and bacteriological results.

The operators are taught to add coagulants to changing waters, and to make the presumptive test for B coli. The operator who never questioned the safety of his home supply, after noting the miracles performed by the various units of a treatment plant, and after seeing the colonies of "bugs" develop on the agar plates from a clear water, in many instances, investigates after returning home and finds that his own supply needs doctoring.

All the propaganda that he has heretofore heard about the necessity for protecting supplies are no longer bunco to him. He takes his work more seriously when it dawns upon him that he is morally responsible for any water-born epidemics that may occur among his consumers.

Three short schools have been given to date, and the results have been satisfactory. The organization of the Texas Water Works Association has been the outcome of the school. Another great benefit, perhaps the most important, is the closer relationship formed between the State Board of Health and the water works officials.

Observations on the Anopheles Mosquito and Sea Water

In interpreting the geographical distribution of malarial fevers and the occurrence of insect carriers of the disease, a more intelligent appreciation of the problem can be gained from a study of the chemical content of water as well as biological environments. A study of the relation between the amount and kind of chemical in water and the presence of mosquitoes in tidewater countries of the United States has been made under the direction of T. H. D. Griffitts, epidemiologist, United States Public Health Service, who describes in the Public Health Reports the results of his investigations.

The investigations were made in the extra-cantonment zones, particularly areas bordering upon the Chesapeake Bay, Hampton Roads or its tidal tributaries, and the Atlantic Ocean at Virginia Beach, Va. Observations were made of the relative breeding habits of three American species of the Anopheles mosquito, A. quadrimaculatus, A. crucians, and A. punctipennis, in relation to various strengths of sea water.

Breeding Habits of Anopheles crucians.—Near Langley Field, Hampton, Va., in September, 1917, a large degree of infestation of A. crucians in barns was found. The production area was found to be a salt marsh ¾ mile away. Subsequent and repeated examinations revealed A. crucians breeding (and producing) generally in the marsh in water showing a salinity of 10,088. (Hampton Roads at Newport News showed a salinity of 10,146.) The A. crucians larvæ were usually found in the salt grass, the smaller and finer of the principal marsh grasses found in this locality. The larger salt-marsh grass grows more abundantly where there is more tidal action, and A. crucians was found propagating in this grass only where its growth was much retarded or where it was dead. No other species of Anopheles bred in this marsh, although a fresh-water pond in the vicinity was producing A. quadrimaculatus, and the fresh water streams near by were producing A. punctipennis.

At Virginia Beach, Va., Lake Rudee, originally a tidal stream and salt marsh, is intermittently formed by a deposit of sand at the beach, which blocks the outlet and impounds salt water. With the addition of fresh water from small streams and from rainfall, the water of this lake becomes less saline. At different times from August to October, 1919, the grassy borders of this lake were found to be harboring A. crucians in great numbers, larvæ of all sizes, or pupæ, were taken at every selective dip. This lake, the salinity of which had undergone no appreciable change during several weeks, conformed to Carter's classification of a "complete" breeding place, i. e., the eggs deposited here hatched and the succeeding stages of larvæ or pupæ through to the imago stage were completed in the same water. The salinometer reading here was 10,068 (the salinity of the ocean water nearby was 10,196). This lake then had 34.6 per cent of sea water at this point. Here was a body of diluted sea water covering approximately five acres, producing A. crucians, a malaria vector, in sufficient numbers to be of decided sanitary importance to the community. Extending to near Lake Rudee and separated therefrom by a strip of elevated land only a few hundred feet wide, was Lake Holly, which, with very rare exceptions, was fresh water. During the time of observations, the highest salinity of Lake Holly was 10,003. This lake was producing A. quadrimaculatus in great numbers. Was not a striking contrast afforded by these lakes in the matter of selective breeding places of the two species? Lake Rudee, containing 34.6 per cent sea water, had an Anopheles production of 100 per cent A. crucians; Lake Holly, practically fresh (1.5 per cent sea water), an Anopheles production of 100 per cent A. quadrimaculatus. The two breeding places were separated by a distance of less than 600 feet. In a stable on this strip of land, on a day in early September, there were collected 67 specimens of A. crucians and 85 specimens of A. quadrimaculatus.

At West Point, Va., York River showed a salinity of 10,110. A pond had been formed by dumping rubbish across a salt marsh, for the purpose of extending a street. The fill was very loose and porous. No culvert had been installed. The main tidal stream was blocked, and at high tide additional salt water entered the pond through the fill. However, the level of the pond varied little between tides. The salinity at the lower portion of the pond was 10,077, or 70 per cent York River water. This degree of salinity would be approximately 50 per cent of that of sea water along this section of the Atlantic coast. A. crucians was breeding and producing profusely in this water. Two hundred feet away, in a different portion of the same body of water, at a point where, owing to the large amount of seepage and the lack of mixing of the waters by wave action, the salinity was only 10,003, A. quadrimaculatus was producing freely.

Larvæ of all sizes and pupæ of A. crucians collected from obstructed ditches (salinity 10,088) in the marsh of Back River, near Langley Field, Sept. 9, 1920, were placed in sea water, salinity 10,160, on Sept. 10, and were not unfavorably affected by the transfer. All but three, which were of the first molt when placed in the sea water, had developed into imagoes within 12 days. Even the smallest of the larvæ developed as well in the sea water as those in fresh water control

Breeding Places of Anopheles quadrimaculatus.—As has been stated, Lake Holly, at Virginia Beach, is practically always fresh. Some years ago a flume was constructed connecting this lake with the ocean, for the purpose of admitting sea water at high tide. In its condition at the time of these observations, salt water came into the lake only at times of very high storm tide; so that not even sufficient salinity was attained to prevent the production of A. quadrimaculatus. In many parts of the lake, prior to the successful control operations in 1920, this species was found breeding freely. The highest salinity found at any time was 10,003, or approximately 1.5 per cent sea water at this place. No species of Anopheles other than A. quadrimaculatus was found breeding in this lake at any time. A. quadrimaculatus was breeding profusely in another fresh-water pond ½ mile distant, and A. crucians bred in the saline Lake Rudee a few hundred feet away.

The small body of impounded water at West Point, previously noted, covered an area approximately 3 acres in extent, in which a growth of reeds and salt grass still remained. As noted, the lower, saline portion of the pond was producing A. crucians. On the opposite side of the pond, 200 feet away, where seepage outcrop rendered the water fresh, only A. quadrimaculatus was breeding. The salinometer reading here was 10,003. The land rises abruptly from the narrow valley, and the protection of the step sides of the valley in which this part of the pond lies, and the vegetation in the water, served to prevent wave action and the mixing of the waters. Consequently, the water on this side of the pond remained almost entirely fresh.

A pond at the upper end of a salt marsh near Newport News produced A. quadrimaculatus in great numbers in 1917. This pond was one of those notorious products of road construction which are found in tidewater countries, where roads are built across salt marshes and culverts are set at too high an elevation or are inadequate in capacity, resulting in the impounding of fresh or more or less saline water above the fill. In this particular case, at times of storm tides, salt water was admitted to the fresh water of the pond. However, the salinity was never so strong or so continuous as to kill the luxuriant growth of cat-tails that occupied practically all of the 2 acres of the pond, except a small portion near the effluent culvert. On one occasion at high tide the lower portion of the pond showed a salinity of 10,076. At this time, breeding was under control. The question naturally arises as to whether or not the larvæ and pupæ of A. quadrimaculatus may resist a relatively high degree of salinity intermittently. The determination of this point has a practical bearing on malaria control and could probably be demonstrated readily by experiments.

In 1918, near Lee Hall and Camp Eustis, Va., Dr. F. E. Chidester and Mr. T. B. Hayne, Jr., then associated with the writer in malaria-control work, collected Anopheles larvæ from the edge of a tidal marsh, in water showing a salinity of 10,048. Two specimens of A. quadrimaculatus emerged from this collection. Chidester and Hayne expressed the opinion that this was a "complete" breeding place. However, in surveys extending over several seasons, under the various conditions and in many salt-marsh areas, the writer has been unable to substantiate their findings.

Fourteen A. quadrimaculatus larvæ of all sizes were collected from a fresh-water pond and put into sea water, salinity 10,160. These were all dead within 12 hours, the larger ones surviving the longest. No mortality was noted in the pond-water controls.

Breeding Places of Anopheles punctipennis.—The writer has never found breeding of A. punctipennis in salt or brackish water, nor is he aware of any report of such breeding. But there is much evidence that A. punctipennis has a wider [illegible] of breeding habits in fresh [illegible] A. [illegible] or A. crucians. It [illegible] mountain springs and branches, and at times in streams and ditches foul with sewage. It is not resistant, however, to sea water.

Twenty-five A. punctipennis larvæ of all sizes, collected from a ditch and a fresh-water lake, were transferred to sea water, salinity 10,160, and all were dead within seven hours. No mortality was noted in fresh water controls.

Conclusions.—A. crucians was found to propagate in sea water diluted to a maximum salinity of 10,088 or slightly more than 50 per cent average sea water. The transfer of A. crucians larvæ, which had started their development in brackish water, to sea water did not unfavorably affect their subsequent development.

A. quadrimaculatus was not found to breed in numbers sufficient to be of sanitary importance in a higher salinity than 10,003, or 1.5 per cent sea water. In one case two larvæ found in water with a salinity of 10,048 developed into A. quadrimaculatus imagoes, but this observation requires confirmation as to whether this species may complete its entire water cycle in so high a percentage of sea water. The question is raised as to whether A. quadrimaculatus larvæ may not withstand a much higher salinity intermittently than continuously. Specimens of A. quadrimaculatus transferred from fresh pond water to sea water, salinity 10,160, were all killed within 12 hours.

A. punctipennis was not found developing in salt or brackish waters. This species breeds under a wider range of conditions than either A. quadrimaculatus or A. crucians, but apparently does not survive in salt or brackish water. Larvæ of A. punctipennis all died within seven hours when put into sea-water.

Cost of Water in 29 American Cities

Some interesting statistics on waterworks operation in various cities are given in the recently issued report for 1919 of the Bureau of Water of Reading, Pa. The figures were compiled by Lewis G. Early, Record Clerk of the Bureau, from the annual reports of various municipal waterworks. The figures cover the year 1913, when practically all the plants were operated by water boards, and 1917, when the commission form of government had embraced the management of many of the plants and war prices prevailed. Figures from 29 cities which have standardized their statistics in accordance with the recommendations of the New England Waterworks Association are given in Table I.

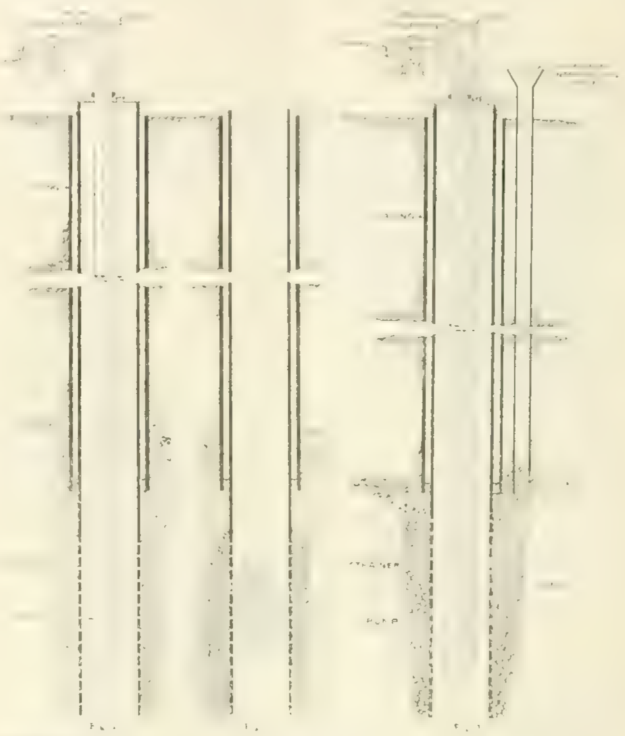
Constructing a Well in a Sand or Sand and Gravel Formation

By JOHN OLIPHANT,

Chief Pneumatic Pumping Engineer, Sullivan Machinery Co.

The standard practice of well drillers is to equip gravel and sand wells with a strainer, designed to shut out the sand from the working barrel of a deep well pump. In time, these strainers become clogged with sand and the flow into the well is thus reduced. By a system of back-blowing, the output from such wells can be permanently increased.

The correct strainer for wells of this class, pumped by the air lift, is a perforated screen with openings of a suitable size to admit the fine material into the well, from which it can be pumped, and to hold back the coarser particles, so as to form a natural gravel filter bed outside of the artificial one.



Sketches Showing Construction of Wells in Sand and Gravel Formation.

TABLE I.—[illegible] STATISTICS OF 29 AMERICAN CITIES.

City.	Average [illegible] cost each person.		Average gallons supplied daily to each person.		Paid for 1,000 gal. by each person.		Percentage of services metered.		Total cost per million gallons, including maintenance and interest on bonds	
	[illegible]	1917.	1913.	1917.	1913.	1917.	1913.	1917.	1913.	1917.
Burlington, Vt.	[illegible]	[illegible]	50.21	49.27	.1429	.1484	88.01	95.00	$ 99.11	$105.83
[illegible]	3.10	3.02	122.70	128.60	.0692	.0643	55.80	71.00	62.91	67.47
Columbus, Ohio	2.36	3.13	88.20	103.80	.0733	.0826	94.34	96.66	55.50	97.26
[illegible]	3.70	4.10	111.30	116.20	.0702	.0966	2.30	2.36	....	....
[illegible]	2.24	2.18	176.00	91.00	.0348	.0656	47.00	93.00	33.08	47.98
[illegible]	[illegible]	2.63	119.00	127.00	.0622	.0567	81.00	84.00	39.53	37.62
[illegible]		2.39	54.60	60.01	....	.1091	82.87	85.70	89.69	100.05
Averages of 7 cities that pump and filter..	2.79	2.87	107.86	96.55	.0754	.0890	64.47	75.39	63.30	76.03
[illegible]	1.82	2.19	141.80	154.00	.0351	.0389	.67	1.49	18.55	26.55
[illegible]	[illegible]	[illegible]	175.00	150.00	.0629	.0878	87.07	99.60	71.83	108.36
[illegible]	1.97	2.07	40.20	40.50	.1343	.1400	99.80	100.00	109.39	127.05
[illegible]	3.50	3.15	95.33	90.30	.1006	.0955	31.00	36.90	92.09	91.92
East Orange, N. J.*....................(P)	3.43	3.55	70.70	65.90	.1329	.1417	53.50	81.00	106.23	107.58
[illegible]	2.94	3.00	136.00	124.00	.0592	.0663	21.73	36.17	30.24	41.96
[illegible]	2.99	3.17	65.41	67.15	.1252	.1293	44.70	54.70	104.15	.
[illegible] Mass.	2.81	[illegible]	78.00	82.00	.0987	.1022	87.80	96.30	62.93	65.00
[illegible]	4.23	3.83	39.20	36.80	.2956	.2851	93.70	96.60	211.92	223.72
[illegible]		1.26	297.00	242.00	.0303	.0482	60.00	67.00	.	..
[illegible]	3.67	4.16	109.00	101.00	.0922	.1128	94.42	97.99	56.49	55.27
[illegible]	1.72	1.92	57.00	73.00	.0703	.0721	75.00	91.20	47.79	66.06
[illegible]		2.97	69.00	77.00	.1108	.1057	56.00	62.00	91.34	80.27
Waltham, Mass.*.......................(P)		2.97	[illegible]	71.60	.0927	.1136	25.00	61.70	[illegible]	46.51
[illegible]	5.24	4.82	65.90	79.00	.2178	.1671	100.00	100.00	160.97	165.05
Averages of 15 cities that pump or filter, [illegible]	3.17	3.33	102.57	96.95	.1106	.1138	62.23	72.18	88.18	92.72
[illegible]		[illegible]	[illegible]	179.00	.0636	.0698	1.87	2.00	37.61	64.00
Hartford, Conn.		3.10	[illegible]	[illegible]	.1153	.1140	98.30	[illegible]	....	....
Manchester, N. H.			[illegible]	57.50	.1060	.0948	78.30	81.90	39.32	39.96
Newark, N. J.		3.52	106.00	113.00	.0786	.0853	56.00	[illegible]	73.18	77.43
[illegible]		3.39	116.00	86.30	.0794	.0825	27.30	28.00	49.53	63.89
[illegible] filter	[illegible]	[illegible]	[illegible]	101.55	.0873	.0900	46.96	59.46	46.73	60.00
[illegible]		3.19	[illegible]	[illegible]	.0976	.1025	[illegible]	70.25	73.92	81.73

*Pump without filtering.
†Filter without pumping.

The force available for getting water into a well is the head, due to the difference between the static level in the water strata outside the well, and the pumping level in the well, minus friction due to the strata and screen. Therefore, the more this friction can be reduced, the greater will be the flow, providing, of course, that an abundance of water is available.

"Back-blowing" can be applied to all wells. The top of the well casing should be sealed; next, by closing the discharge pipe while the air lift is in operation, the air will be forced through the foot piece and will drive the water ahead of it out through the strainer and float the finer sand. Then, by opening the discharge, the flow will resume its course toward the surface and bring a portion of the floating sand with it. By a repetition of this operation and by increasing the back pressure if necessary, all of the fine sand immediately outside of the strainer will be drawn into the well and discharged at the surface, and the coarser gravel will be collected outside of the screen in such quantities to shut off the sand and increase the flow into the well, without changing the piping in the well. This process may be repeated at any time, so that the screen and adjacent strata can be kept clear.

When wells are drilled in rock, the action of the drilling tool forces the cuttings back into the crevices in the rock. These may be loosened and pumped out of the well in the same manner.

In the case of wells in fine material and quicksand it is often possible to set a strainer in the sand and drill auxiliary holes alongside the well down to the top of the strainer. Then foreign gravel may be dropped down which will roll in alongside of the screen and take the place of the sand pumped out—often incrasing the yield four-fold, by affording outside of the gravel bed a larger area through which the water may leave the sand.

In the accompanying cuts is shown well construction under three conditions:

1. A well with a properly constructed strainer for air lift work, placed in a mixed layer of sand and gravel.

2. Illustrating the gravel collected around the strainer after the finer sand has been drawn into and pumped out of the well. It will readily be seen that this treatment forms a "gravel" strainer outside of the metal one and greatly increases the inflow area—keeps the openings of the screen full and open, and greatly increases the capacity of the well.

3. Where the water bearing layer consists of fine sand, or quicksand, it is sometimes necessary to introduce gravel through one or more auxiliary holes drilled near the main well and terminating in the top of the sand layer, so that when the sand is removed by "back-blowing," the gravel will roll in around the screen and form a gravel screen outside the metal one as in the first instance. The gravel should be selected and clean and practically round; and of a size from that of a small walnut up to one which will pass through a 2-in. mesh.

New Method of Lithographic Printing of Charts

The division of charts of the U. S. Coast and Geodetic Survey has recently developed a new method of producing lithographic printing plates of charts engraved on copper, which constitutes a notable advance over previous practice in that office.

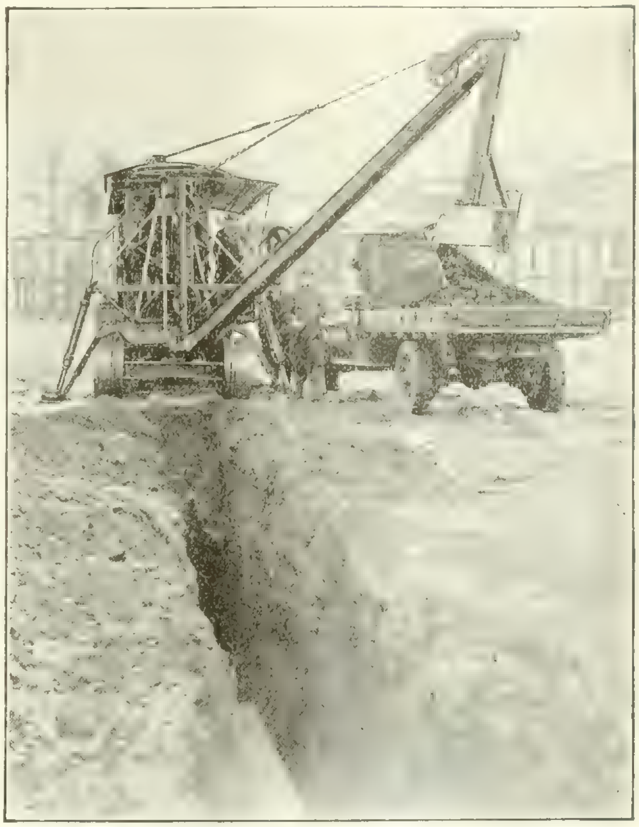
The old methods of printing either direct from the copper plates or by transfer from copper to aluminum resulted in considerable distortion of the finished product. Measurements of a large number of charts so printed indicate that this error ranged from 1 part in 30 to 1 in 40. By the new method this distortion is eliminated, and charts true to scale are now being produced.

The new method is as follows: An impression from the engraved plate is pulled on a special highly calendered unsensitized photographic paper which is backed while it is still wet and before it has had a chance to change its dimensions. The print is then photographed, the intensely white glossy finish of the paper affording an exceptionally good contrast to the black of the work, so that negatives are readily produced which require a minimum of recruiting. The printing plate is then prepared by the usual methods for a photolithograph chart.

This new method will be applied to all the engraved charts as rapidly as practicable. The application, however, must naturally be a gradual one, extending over a period of some years, and in consequence no material reduction in correction work in the engraving section can be expected in the immediate future.

New All Steel Traction Excavator

The Keystone Driller Co. of Beaver Falls, Pa., has placed on the market a new 14-ton all-steel traction excavator having a number of improved features. The machine is equipped with two cylinder 6x6 engine developing 32 HP. and giving a 4,000-lb. thrust to the skimmer scoop when digging hard materials, old macadam, asphalt or hard packed gravel. The boom is 18 ft. long providing horizontal crowd for skimmer of 14 ft. Machine is equipped also with hydraulic side jacks which are operated by a pump controlled by a 6-way valve at the operator's hand. He raises and lowers them to the ground by throwing the lever of the valve. Tread wheels are 55-in. in diameter; have 18-in. wrought steel tires and are equipped with chain cleats fastened through slots in the wheels by means of pins which can be knocked out with two blows of a hammer. The front wheels are 36 in. in diameter and have 16-in. wrought steel tires with bolted removable cutter bands. Wheel base is 9 ft. 6 in. The boiler is 40 in. x 72 in. of the vertical fire tube type.



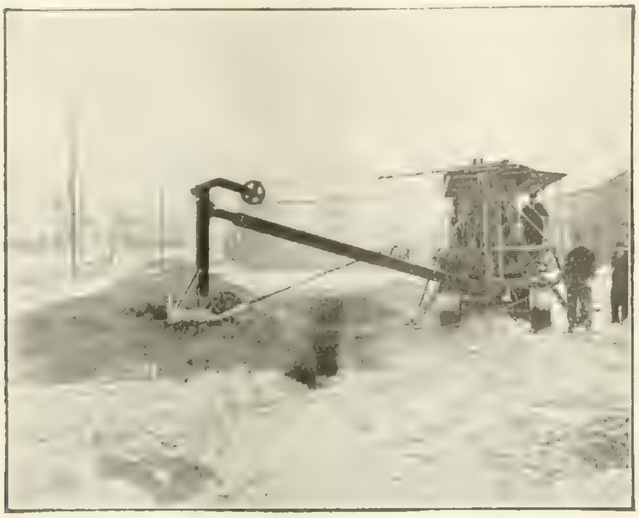
Dumping Ditcher Scoop Into Truck. The Scoop Is Working in 4 Ft. of Water.

The new flat bail skimmer scoop is mounted on the boom upon six trolleys. The improvements in the construction of the bail give it actual 3/5 to ⅝ yd. capacity and the scoop will, it is stated, fill a 1½ yd. wagon at two shots. Teeth are of manganese steel and body of scoop is made of rolled plate, giving it adequate strength for digging in old pavements or hard materials. The bottom is hinged in front and the scoop is self-cleaning. It is used in excavations up to 10 or 12 ft. in depth. It is claimed it is practicable to run wagons over a bank 6 or 7 ft. in height for loading beside the machine, whose boom swings through an arc of 180°. On excavations deeper than 7 or 8 ft., it is advantageous to make two cuts.

The machine also can be equipped with a new drop bottom ditcher scoop, which is hinged in front the same as the skimmer, but is operated toward the machine in digging. Thus the keystone always "stands on the solid" and is free from all danger from caving. The depth capacity of the [illegible] is about 20 ft. The illustr[illegible] machine operating in a ditch 12 ft deep w[illegible] of water in the [illegible], which is no impediment to [illegible]. The machine is moved backward away from [illegible] is excavated.

In changing from one scoop to another it is only necessary to remove the skimmer, put on the attachments and bolt on the ditcher sticks and scoop as shown in the illustration.

The ditcher scoop is made in five widths, 14 in., 18 in., 24 [illegible] and 36 in., and overcuts [illegible] in. By [illegible] the boom off the center [illegible], however, it is stated, a ditch any width up to 20 or 25 ft. can be cut with any of these scoops. The 24-in. scoop is about half-yard capacity and the larger and smaller sizes are proportionate.



Back Filling with Ditcher Scoop.

In back filling with the Keystone Excavator, either of the two scoops, the skimmer or ditcher, can be employed. If it is advisable to set the machine on the outside of the spoil pile from the ditch, the skimmer can be used and the material pushed into the ditch or loaded into the scoop and dumped through the bottom. If, however, it is necessary to set the machine across the ditch from the spoil pile, in the manner shown in the illustration herewith, the ditcher scoop is employed and material either dragged into ditch or loaded into the scoop and dropped through the bottom.

It is claimed for the Keystone, with its half-circle swing, that it can be operated alongside a row of buildings or trees, or a street car track without interfering in any way, since the body of the machine does not swing. The machine has two traction speeds, 1 and 3 miles per hour, and will make tractions of 10 to 15 miles in 10 hours. Long jumps of 20 to 30 miles have been made in two to three days.

Keystone can be equipped with boom extension and ½-yd. clamshell for unloading cars or very deep ditching or cellar digging.

Aluminum Sulphate Used at Water-Purification Plants in Illinois, 1920.—Data collected by the Illinois State Department of Health relative to use of aluminum sulphate at 22 of the water-purification plants in Illinois during 1920 show that 2,300 tons of alum were used, ranging from 5 tons at some of the smaller plants to about 780 tons at the largest plant. The cost ranged from $24 to $160 a ton. Analyses made at some of the plants show Al_2O_3 17 to 17.25 per cent, insoluble matter 0.1 to 0.2 per cent, Fe 0.5 to 0.75 per cent. In some instances the alum is purchased without specifications, and in others the specifications vary considerably. The alum has been purchased from four different companies.

Water Resources of Connecticut—The U. S. Geological Survey has published several reports on the water resources of Connecticut and others are in preparation. The latest publication is a report by Harold S. Palmer on 13 towns in the vicinity of Norwalk, Suffield and Glastonbury. This report is published in Water Supply Paper 470; copies can be obtained free of charge by writing to the Director, U. S. Geo[illegible] [illegible]ton, D. C.

Personals

F. H. Dryden has been appointed city engineer of Salisbury, Md.

M. C. Hutchins has been reappointed city engineer of Charlotte, N. C.

William Sachs has been appointed borough engineer of West Haz[illegible], Pa.

Delmont J. Schneider has been appointed city engineer and [illegible] commissioner of Pocatello, Idaho.

W. H. Harrington, engineer of the West Side Irrigation District, has been appointed city engineer of Tracy, Calif.

Claude E. Belk, purchasing agent for the Sinclair Refining Co., has been appointed city manager and purchasing agent of Houston, Tex.

[illegible] received the honorary degree of Doctor of Science from Ohio Northern University, at the recent celebration of the 50th anniversary of the founding of the university.

H. A. Stevens, former city engineer of Joliet, Ill., who left there ten years ago for Corpus Christi, Tex., to take a similar position, has returned to enter into partnership with C. D. O'Callahan, civil engineer, formerly head of the city engineering department of Joliet.

C. A. Jennings, district representative of Wallace & Tiernan Co., Inc., Newark, N. J., gave an illustrated talk before the engineering students of Valparaiso University, Valparaiso, Ind., on May 6th. The subject was "The Uses of Liquid Chlorine as Applied to Sanitary Engineering Processes."

Walter A. Shaw, formerly member of the Illinois Public Utilities Commission, has opened offices at 30 North La Salle St., Chicago, where he will engage in a consulting engineering practice, specializing in municipal engineering and construction work. Mr. Shaw was engineering member of the commission for seven years.

Former Governor Manual Ballazare of the northern district of Lower California, will be appointed head of the Mexican engineers to be named members of a joint commission with the United States to study the Colorado river situation. This commission is to make recommendations for the permanent control of the flood waters of the Colorado, it is said.

M. J. Stinchfield, Jr., of Valparaiso, Ind., has been appointed assistant state engineer by the Indiana State Department of Conservation. The engineering division of the department was created by the last legislature and has under it matters pertaining to drainage, water levels, stream pollution and water power. Prof. W. K. Hatt of Purdue University was appointed state engineer without additional salary from the state. He will supervise the work of the division.

Industrial Notes

The Engineering Advertisers' Association of Chicago held its last meeting prior to summer adjournment at the Great Northern Hotel, Chicago, on June 7. Charles Piez, president of the Link-Belt Co., addressed the gathering on "Advertising and Selling from an Executive's Viewpoint."

The Equipment Corporation of America, having offices and plants in Chicago, Pittsburgh and Philadelphia, has just purchased another plant at Primos, Delaware County, Pa. This new acquisition makes a total of five plants which the company operates, in the rebuilding of all classes of contractor's equipment.

Chris D. Schramm & Son, Inc., manufacturers of engines, compressors, pumps, hoists and mixers, West Chester, Pa., is enlarging its New York sales effort. The former offices at 480 Lexington Ave., and 140 West St., are being merged into one and moved to the new show room at 54 Dey St., New York City. Here the company will have the entire first floor with over 3,500 sq. ft. of floor space.

The Badger Meter Manufacturing Co., of Milwaukee, Wis., announces the opening of a sales office in Kansas City, Mo., at 414 Interstate Bldg., in charge of R. M. Stotler, Western sales manager. Associated with Mr. Stotler are Charles Barry and Luke L. Ballard. These gentlemen are well known to the water works trade throughout the southwest, as they have been engaged in the meter business in that territory for a number of years.

R. M. Stotler.

The Hauck Mfg. Co., Brooklyn, N. Y., manufacturers of oil burners, oil forges, oil burning appliances, etc., has elected as its president, Henry T. Gerdes, mechanical engineer and manufacturer of New York; first Vice-President, M. C. Hauck; second Vice-President, A. B. Hauck; third Vice-President, H. H. Kress; Treasurer, A. H. Stein; Secretary, J. Lutz. Mr. Gerdes, who succeeds the late Arthur E. Hauck, is a graduate of Stevens Institute of Technology, and was for many years manager of the Treadwell Engineering Co., of Easton, Pa.

Railways and Excavation Monthly Issue

ENGINEERING AND CONTRACTING

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The four rotated special monthly issues and 4 quarterly issues of E. & C. (52 in all) entirely cover the civil engineering and contracting field at $4.00 a year. Any one of the four special monthly issues may be subscribed for as a monthly at $1.00 a year. The special quarterly issues relate entirely to foreign engineering and construction practice. The *articles* in the first two issues of each month completely cover the municipal engineering and contracting field. The *articles* in the first and fourth issues of each month completely cover county engineering and highway engineering and contracting. The *articles* in the 3rd and 4th issues of each month completely cover steam and electric railway location, design and construction. See the "masthead" on the first page of the Weekly News Section for information about our weekly contract news.

Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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A Brazen Act

Elsewhere in this issue we quote in full the protest of the Western Society of Engineers against the enactment of a new public utilities bill now pending in the Illinois Legislature. The author might have entitled it "A Bill to Make the Regulation of Public Utilities as Expensive as Possible, to Make All Members and Employees of the Regulating Body subject to Political Appointment, to Provide that All may be Appointed from One Political Party, to Eliminate Civil Service, and to Reestablish the Customs which formerly Existed as to the Issuance of Free Transportation (otherwise known as passes) but Which were Abolished Many Years Ago because of the Corruption to Which They Lead." Such a title would be merely a summary of what any person may read for himself in the text of the bill.

It is truly fit to warm the heart of either novice or master in the art of patronage. In spite of the fact that thirty-seven of our state utility commissions have only three members, six have five commissioners and only one has seven commissioners, it is now proposed that Illinois increase her commissioners from five to seven, each with a salary of $7,000 per annum as at present. But this is only 55 per cent of the story: Illinois is to have eight assistant commissioners at salaries of $5,000 each. Here is $89,000 per year in salaries of commissioners and assistant commissioners as against $35,000 annually for salaries of the present commission. However, the framers of our bill appreciate the disadvantage of such rigidity of organization, and to remedy the defect they provide that the commission may designate any person to make investigations and to conduct the same as prosecutor without restrictions as to salary. This would permit a special prosecutor in each county or city to act as an additional assistant commissioner.

Harmony being essential to the success of any organization, the bill provides that the fifteen commissioners and assistant commissioners shall be appointed by the governor without restriction as to political party. In 1913 it was thought desirable that each party be represented, and the utilities law of that year provided that not more than three of the five commissioners should be of the same party. In 1917 this was changed by the removal of the party restriction, and the provision that the incoming governor should appoint the entire commission. From the standpoint of patronage this method apparently cannot be improved upon; and the able men who are handling the measure do not waste their efforts in a fruitless field, but immediately make the method of the most service by tripling the number of appointments to be made under it.

Further harmony and efficiency are to be secured by the removal of all employees of the commission from the classified civil service. This additional provision will make the organization 100 percent efficient—politically.

Not only must harmony be maintained, but certainly commissioners cannot do their best if overworked, and very careful provision is made against such danger. Article VI. says "Any city exercising powers under this act shall have authority to exercise such powers by municipal ordinance, or otherwise, as such cities shall determine." Many city councils will unquestionably avail themselves of this chance of adding to their powers, thereby greatly reducing the volume of business coming before the commission.

For definite reasons we prefer to see control of all utilities retained by the commission, for at the very least, that body has utility affairs as its primary business, and presumably has a corps of competent experts in its service. Councils, on the other hand, particularly in the smaller communities are likely to attempt regulation without the ability to conduct it intelligently. It seems needless to comment further on the reduction of commission business coincident with an increase of 200 per cent in its membership.

This bill is so completely pernicious that we have no hesitancy in saying that its passage will practically stop the development of utilities in Illinois; yet as we go to press there appears strong probability of its success. Such a condition can arise only from a combination of incompetence and indifference to the best interests of the public.

That we may avoid willful or other misinterpretation of the foregoing, we now specifically state that we know there are many honest and capable men in public office, and that we do not anticipate that all members of the proposed commission would be corrupt. But we have endeavored to outline certain ways in which this bill presents unequalled opportunities for corruption, and from our contentions on these points we abate nothing.

Light Installation Versus Heavy

Even should Henry Ford fail to accomplish many of the things set forth in his plan to "jitneyize" the railways, it is not too much to expect that his efforts will bring a very substantial net benefit to the community and a worthy satisfaction to himself. Mr. Ford's proposals are likely to appear more novel to the public than to engineers, for the former has become so accustomed to seeing each structural or mechanical production exceed its predecessor in size and weight that to a large extent it looks upon such growth as the one natural thing to expect. Engineers, on the other hand, while not all immune from the public's weakness in accepting as universal, that which is merely common, recognize as a class that there is no inherent economic virtue in size and weight.

Most spectacular has been the advance of the steam locomotive from the "John Bull" and "Puffing Billy" of a century ago to the articulated "Mallet" of today, with its attendant requirements of ever increasing weights of rail and strengths of bridges. We believe that the heavy engine is here to stay, or perhaps to be supplanted by even heavier, for it is difficult to believe that a heavy freight traffic can ever be handled as cheaply by a multitude of small tractive units as by a few large ones, each hauling a great tonnage, and we do not think that even Mr. Ford disagrees with this general view.

The opposite extreme from the heavy engine and corresponding roadway exists probably in some of the narrow gage roads. Unpopular as narrow gage has been for many years, it is still probable that certain lines would have been better built to such a scale; and in this view we are very sure of concurrence by some of the investors in broad gage railways in poor territory.

With the present development of the auto truck fewer branch lines and minor lines of railway will be built; and the narrow gage in particular will probably be constructed hereafter only under very rare conditions and for special purposes such as ore hauling.

The light standard gage line, while still having a useful function, will presumably be crowded out of numerous places by the self-propelled highway vehicle. Lines of intermediate weight will probably continue to prove economic for certain services, but it appears to us that such services will decrease considerably as compared with both heavier and lighter installations. This prediction is based upon the belief that the advantages of the hauling of freight in smaller, faster, and more flexible units, when added to the savings in cost of track and bridges made possible thereby will result in a net economy of transportation of moderate traffic over light lines as compared with lines of medium weight structures and equipment. Mr. Ford's experiments, if carried far enough, may decide the matter definitely.

It seems obvious that local passenger traffic can be handled most satisfactorily in small units up to the point where the density of traffic results in insufficient headway, after which longer trains must be used. The suggestion of a ten minute transcontinental service by single motor driven cars to displace the present long trains seems altogether unlikely of accomplishment, for a ten minute difference in time of departure or arrival on a four or five days' trip is of too little significance to count with more than the rarest traveler. Quite aside from economy of operation, it seems most improbable that the single passenger car can be made to compete with the train in comfort or convenience en route, and the "traveling public" is possessed of a liking for luxury which may not lightly be ignored. We trust that Mr. Ford does not overlook the preference which many persons have for the Rolls-Royce above his own useful and worthy production.

The field of electric traction affords some very pertinent examples. The one-man street car was heralded by some as the displacer of other types, but the displacement has only been partial, and the older type seems likely to remain wherever the hauls are long and the volume of traffic considerable. Reductions in the weight of cars without reduction in carrying capacity have in some cases been advantageously effected. The slowness of the introduction of electrification on main line roads has been a source of surprise to many. Beside the ever present inertia to be overcome by innovations, the change seems to have been hindered by the predilection of certain engineers for heavy construction. This is manifested in the heavy steel poles set in massive concrete on some of the Eastern lines, where it has been declared that only the heaviest traffic could warrant the cost. In contrast with it we have the light and serviceable construction, largely of wooden poles, in use on the mountain divisions of the Chicago, Milwaukee & St. Paul Ry. It is hard to understand how other engineers failed to appreciate the feasability of such construction.

The Expert Fee Scandal Arouses Chicago Voters

Elsewhere in this issue we give an account of the work of our editor-in-chief in investigating the very high fees paid to building appraisers in the city of Chicago; and we also print his recommendations to the Finance Committee of the City Council for a suitable basis of conducting and paying for such work in the future.

Both Mr. Gillette's employment by the Finance Committee, and the editorial in our May 4 issue which lead thereto, were prompted by the purely professional desire to remedy a conspicuous abuse in the appraisal field. In its issue of July 21, 1920, Engineering and Contracting published an editorial calling attention to the excessive character of these fees. The matter was also taken up by several Chicago daily papers and pressed with increasing vigor up to the present time.

City officials subjected to this attack very naturally countered with the charge that it was mere political propaganda, although there were in addition several specious arguments intended to show that the city was getting its money's worth or better from the experts employed. Engineering and Contracting leaves to the various dailies the statement and defense of their motives, if such are thought necessary. Our own object was solely as already stated.

Defeat of the Republican ticket of County Judges, which was being supported by the city administration, was the immediate political aim charged; and this very defeat occurred at the election of June 6, the entire Republican ticket being badly beaten. The victorious ticket, although bearing the Democratic Party label, was in reality a coalition ticket, in the preparation of which Republican leaders had participated, and on which one-half the candidates were Republicans opposed to the local organization of their party.

Engineering and Contracting would be lacking in candor to do other than admit its pleasure at this outcome, for the election was primarily an issue between the political machine now in power in Chicago and the entire remainder of the voting population; and the machine's success would not only have encouraged the expert fee abuses but would have forecast a long period of like abuses and inefficiency such as now make the cost of public work and administration so great. Leaders of the defeated organization admitted freely and publicly that the fight on appraisers' fees had cost them 50,000 votes or more.

But a much more significant result than that of the judicial election appears in the majority of about three to one which was cast against the proposal to issue some $9,000,000 bonds for the construction of a new county jail. It is believed that there is general recognition of the need of a new jail in Cook County, and to us it appears very clear that the overwhelming defeat of these bonds was largely due to the unwillingness of the public to entrust further large sums to the care of the politicians who were responsible for the employment of experts at rates many times in excess of the highest that could be assigned on any reasonable basis whatsoever.

Our criticisms of expert fees have been directed chiefly toward those paid to building appraisers, but it is not to be overlooked that the land appraisers have received huge sums which, on their face, appear even more excessive. These also are being taken up in the investigation which the Council's Finance Committee is making.

The "Fancy" Salaries of Railway Officers

In the indictments which somebody always is drawing against the managements of the railways there always is included the charge that they pay their officers excessive salaries. Hardly a day passes that somebody does not publicly and solemnly allege that if the railways would eliminate the "waste" due to "fancy" salaries they could pay their employes more or reduce their rates. The other day a member of Congress introduced a bill to provide that in future no railway company pay any officer more than $15,000 a year without the previous approval of the Interstate Commerce Commission.

Of all the asinine charges made against the managements of the railways this one about excessive salaries is perhaps the most asinine. It may cause some astonishment to those who believe the railways waste large amounts in salaries to be told that if in the year 1920 they had not paid a dollar of salary to any of their 22,000 general and divisional officers their total payroll would have been only 2.5 per cent less than it was, and their total operating expenses would have been only 1.7 per cent less than they were.

All of the alleged "fancy" salaries are included in those paid to the general officers. The general officers include all the chairmen, presidents, vice-presidents, general managers, traffic managers, and so on; and many people believe that since some of these officers receive $50,000 to $75,000 a year the total amount paid to them is enormous and the burden imposed on the railways and the public very great. People who think thus will be surprised to learn the statistics of the Interstate Commerce Commission show that if the railways in the year 1920 had not paid a dollar of salary to any of their general officers their operating expenses would have been less than six-tenths of 1 per cent less than they were. To state the matter in another way, if not a dollar of salary had been paid to any general officer the operating expenses would have been 99.42 per cent as much as they actually were.

In 1916 and 1917 salaries of all officers were 1.4 per cent of the total earnings; in 1918, 1.3 per cent, and in 1919 and 1920, 1.5 per cent. In other words, in these years, out of each dollar that the public paid for all kinds of railroad transportation, freight, passenger, mail and express, the officers as a whole received from 1.3 ct. to 1½ ct. In 1920 out of each 100 ct. the public paid the railways, the general officers, including all those with alleged "fancy" salaries, received 7.5 mills.

In recent discussions of needed reductions of the railroad payroll, it repeatedly has been suggested that if wages are to be reduced the salaries of officers should be reduced in proportion. Let us see, then, what have been the relative increases in salaries, on the one hand, and wages on the other, since 1916. In 1916 the average salary of a general officer was $4,508, and in 1920 it was $5,542, an increase of 20.7 per cent. In 1916 the average salary of a division officer was $1,998, and in 1920 it was $3,319, an increase of 66.1 per cent. The average pay of passenger locomotive engineers and motormen in 1920 was $3,310, or only $9 less than that of division officers. Between 1916 and 1920, however, the average compensation of all employes increased 104 per cent, and it is now almost 114 per cent more than in 1916. Since the advances in salaries of officers as a whole have been relatively less than half as great as in the wages of employes, and have not at any time even approached the increases in the cost of living, while the advances in wages have exceeded the increases in the cost of living, it is wholly unfair to suggest that if wages are to be reduced salaries shall be reduced in the same proportion.

The only year for which the salaries of all officers receiving $20,000 or more have ever been published is 1917. The figures for that year showed there were 200 officers who received this much or more and that their total compensation amounted to $6,644,074. This was 2.3 mills out of each dollar of operating expense the railways incurred in that year and 1.6 mills out of each dollar they earned. There were only 29 officers who received $50,000 or more and their total compensation was $1,900,000. This was two-thirds of one mill out of each dollar of operating expense the railways incurred and one-half of one mill out of each dollar of their total earnings.

These figures demonstrate conclusively that no reduction of salaries that conceivably could be made would have any perceptible effect in reducing the operating expenses that the railways incur or the rates that they must charge. The fact is that salaries as a whole in the railway business are low as compared with those paid in other industries, and that even the largest salaries paid are small compared with the earnings of successful men in other lines of prefessional and business activity. When people talk about salaries of $25,000 to $75,000 a year in the railroad business being excessive, they do not stop to think that successful men in almost all other lines of business make larger incomes than this. There is hardly an opera star or a moving picture star who does not earn much more. The public goes to the movies night after night and indirectly pays Charlie Chaplin many times as much for getting his face bespattered with a pie as it pays any man in America for managing a great railroad system.

How long would men of ability and ambition enter or stay in the railroad business if they knew that there was no opportunity in it to earn incomes comparable with those earned in other lines of professional and business activity? Hardly a month passes when men of this kind do not leave the railroads to accept higher salaries than the railways will pay. Remove all the large prizes from the business and within a generation there will hardly be left in it a man of ambition and abilty. But it is absolutely necessary to have such men in important positions if the railroads are to be efficiently developed and managed; and if they are not efficiently developed and managed their service is bound constantly to grow worse and more expensive to the public.—From an editorial in Railway Age.

Railroad Management and Success in Life

President Willard of the Baltimore & Ohio R. R. in a recent statement before the Senate Interstate Commerce Commission, referring to the criticism sometimes made of supposedly high salaries for railroad officials, said:

"It is strange that the position of a railroad official is the only one in which it is discreditable to succeed."

Mr. Willard mentioned as one illustration the case of an important railroad official who had been receiving an annual salary of $35,000, but who resigned to enter an industrial enterprise because of the more promising future; and he asked, "Is it a good thing for the transportation service to lose men of that caliber?"

Mr. Willard's question can be easily answered. It is a disastrous thing for the railroads, and that means for the country, for the transportation business to lose men of the highest possible business caliber on the mere matter of what broadly speaking is a few thousand dollars one way or the other. A man who can manage a great railroad and so develop its facilities as to furnish better transportation and to create larger traffic, is worth to the country, not merely to the railroad, but to the country at large, far more than any salary that any railroad man in America is paid.

The cry against high salaries for railroad officials is really a cry against efficiency in management, and against success in developing transportation, which is more essential really to the prosperity of the country than is production. Men of the caliber required to adequately handle railroad business could in private business activities very generally make far larger earnings than the salaries paid to them. The aggregate salaries paid to all of the higher railroad officials of the country is a mere bagatelle as compared with the importance of their work. It is not a question of salary, but a question of efficiency in bringing about better transportation, more effective handling of freight and passengers, and the creation of more business for the good of the country involved in this whole subject.

If this nation would put aside the thought that prosperity is a crime, that success must forever be denounced, that "cheapness" is to be desired, and unite in a whole-hearted support of things which make for national progress, for a recognition of the fact that a man who can command a great salary or develop a vast business, gives far more to the country in the doing of this than any possible amount which he individually can earn for himself, it would be the country's material salvation.

Some men are born for great generalship on the battlefield; some are born with a spirit of poetry; some with a spirit of the artist; some as great orators; and others are born with the initiative and the power of vast constructive enterprises. The one is just as much the product of nature as is the other. Not every man can write a great poem; not every man can paint a picture before which the world will stand with head uncovered; not every man can by the power of eloquence move an audience; not every man can be a leader in science and art; not every man can be a great upbuilding force in the opening of mines, the building of furnaces and mills, or the creation and the management of railroad systems.

To decry success in one line [illegible] to decry success in another. To denounce the painter or the sculptor, or the orator for his creative work beyond that of other men, is just as silly and absurd as to denounce the constructive power of the man who can build or run a railroad, who can build or manage a great factory, or open a mine; or the chemist who with his touch can change the simple things of the material world into the marvels which we are constantly using.

Mr. Willard is right. Railroad officials, when efficient for the great responsibility which rests upon them, are entitled to high salaries. And this is true as to other enterprises.—From an editorial in the Manufacturers' Record.

Franklin K. Lane

He left no will and no estate.—New York Tribune news item.

We probably should not have been so quickened to notice editorially the death of the former Secretary of the Interior had it not been for the laconic sentence quoted above, which is the end of probably the last news item Franklin K. Lane will ever get. Publicity rushes back for news of the living. Yet we cannot let this last word of his newspaper epitaph go by without comment. As Secretary of the Interior, Lane was ipso facto Secretary of Mines, and many of us have come in personal contact with him. We know that he left an estate—a legacy to the American people beyond the ability of accountants to evaluate. He left the memory and the inspiration of a high soul, a clean life, of a great ideal of public service, of a career devoted to humanity, which great things so occupied him that he never found time for the accumlation of cash. We know that he left a will—a will to live intrepidly and without currying favor, and to die serenely, awaiting the orders of a Destiny which he frankly recognized was beyond his comprehension. "I accept" was the creed he dictated on his deathbed.

To those who place, as the great objective, business, commerce, the accumlation of lands and bonds—to the greatest commercial country in the world—such an estate, such a legacy as he bequeathed to the world, is priceless. It is not an isolated case, and reveals the deep-set foundation of the nation, on which the busy superstructure of bartering, toil and hubbub, and the great constructive work of industry, is reared.

During the war, a member of the War Cabinet whose entire record was that of a money-getter once remarked to Secretary Lane in scorn, "Queer that these doctors, experts, and scientists who are so busy around here don't seem to be able to make any money." "Did it ever occur to you," rejoined Secretary Lane, with finer scorn, "that there were people with other aims and ambitions than to make money?"

It is said of estates that man cannot take them with him when he passes into the Shadows which Franklin K. Lane entered at Rochester. But the great estate he left was not of that kind; he takes it with him wherever he goes—and he leaves it all to the country.—Editorial in Engineering and Mining Journal.

Why Engineers Fail to Qualify for Executive Railroad Positions.—"When we consider the high character of the engineering forces as a whole, why is it our executive officers, general managers, general and division superintendents are not, to a greater extent at least, drawn from the engineering ranks? It is not because of discrimination, for it is a fact that the positions mentioned are invariably filled with men from any department, who appear to have the necessary qualifications. What is the answer? Is it not that your experience is confined too closely to engineering lines and not enough to the other things necessary to qualify you for the advanced positions in operation? This may not have been a fault of yours entirely; it may be partly chargeable to lack of encouragement along these lines."—E. P. Bracken, Operating Vice-President C., B. & Q. R. R., in address to A. A. E. section of that railroad.

French Railway to Electrify its Alpine Lines

The Paris, Lyons & Marsellies Ry. has been in the past slow to realize the possibilities of electrification in the Rhone valley. Up to 1914, it had only electrified one section of line: that from Fayet to Valloreine. Two stations supplied the power necessary to the operation of this line, one of which developed 5,500 H. P. and the other 3,000 H. P. The line under construction from Nice to Coni, when war broke out, was being electrically equipped.

The P. L. M. Co., according to the French Commission in the United States, now proposes to electrify all its lines, starting with that from Lyons to Marseilles, which bore a traffic of 14,000,000 tons of freight per kilometer in 1913. This line also serves both directly and indirectly Modena, Grenoble, St. Etienne, Geneva, Roanne and the lines from Tarascon to Cette and Grenoble to Marseilles. So inadequate are the facilities of this last line at present that much of the traffic has to be diverted via Valence.

The electrification of the Lyons-Marseilles line will require 200,000 Kw. of which 150,000 Kw. must be supplied by the Alps-Rhone region. The power stations to be built along the Rhone will be able to furnish this power, and plans are being made accordingly. The P. L. M. Co. further intends to construct a power plant itself at Mondragon. Further, the Ministry of Public Works plans to place at the company's disposal the surplus power which the Government's hydroelectric plant at Merargues will have available for distribution after the needs of the farmers of the neighborhood are satisfied. It has been in fact proposed that the entire output of the Merargues station be turned over to the P. L. M. Co. until such time as it shall have completed the construction of its own plants and transmission stations.

Further, the P. L. M. proposes to develop the power resources of the Bessorthe River. The upper portion of the Bessorthe valley is plateau, on leaving which the river drops some 1,100 meters in 2½ kilometers. The upper basin would permit the construction of a reservoir of 15,000,000 cubic meters capacity. The fall of 1,100 meters would make available, once the reservoir is constructed, 10,000 Kw., an important portion of the power needed by the company in this neighborhood.

The Government Railway Administration had already electrified a section of line in this region in 1911. In the same year, it decided to extend its electrified line another 35 kilometers from Mure in Dauphine to Gap in Haute Provence. For this purpose, it had under construction a power plant and reservoir which since completed, make available 4,500 H. P. The surplus power derived from this station is sold to the inhabitants of the surrounding villages for lighting and other purposes.

If the saving in coal on the Government's line from Mure to Gap be taken as basis of comparison, the electrification of the P. L. M.'s Lyons-Marseilles line should mean an annual coal saving of 5,000,000 tons.

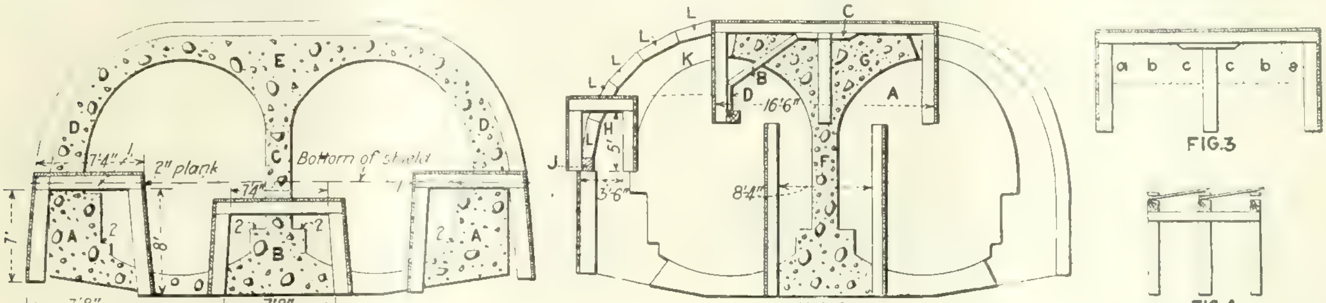
Rail Wages Cut 12 Per Cent by U. S. Board.—An estimated yearly saving of $400,000,000 will result for the railways as a consequence of the U. S. Railway Labor Board's decision of June 1 authorizing an average 12 per cent wage cut for railroad employes. Reduced cost of living and reduced wages in other industries were the major factors on which the wage cuts were based by the board. The decision points out that the adjustment period has produced conditions "in whose burdens all have to share." It says the wage problem with which it dealt is an "economic one" and should not be regarded as "a struggle between capital and labor or the managements and the employes." In a supplemental memorandum the board points out that during government control the wages of railway employes were increased from an average of $78 in December, 1917, to $116 in January, 1920, or about 20 per cent. The board's decision last year, effective May 1, 1920, increased wages 22 per cent, or to an average of $141 per month. After this increase the railway workers, it says, were receiving an average increase of 81 per cent more than they were getting before federal control, and about 10 per cent of them, chiefly the lower paid unskilled workers, had received increase in excess of 100 per cent. The new scale becomes effective July 1, the date set for abrogation of the national working agreements.

Methods of Tunneling Through Soft Ground

The greater part of the subway construction in New York City has been carried on under normal air conditions by tunnelling, open cut, and cut and cover methods. In a recent issue of the Engineering and Mining Journal Mr. Robert W. Jones gives an interesting description of the methods followed in driving through unconsolidated materials, under normal air. The matter following is taken from the article:

The tunnel under discussion was to be carried through a morainal deposit varying from a clean sand to heavy gravel, with pockets of loam and in spots an abundance of boulders up to 3 and 4 ft. in diameter. Water was encountered in places, but not in quantity. The dry sandy sections were unstable, and the tendency of the ground to run as soon as the support was released was quite evident. The boulder section made dangerous roof conditions. The wet sand and loam would hold up for a time without support and then unexpectedly fall.

The tunnel was opened from two main faces, or rather under two conditions. At one face a metallic roof shield was used and at the other the entire support and protection depended upon timbering. The descriptions simply give the general ideas as laid out in advance of active work and maintained remarkable consistency throughout construction.



Cross-Sections of Subway Excavations and Method of Concreting.

The shield-driven tunnel was mainly through material that was of a loamy nature, but which carried an abundance of medium-size gravel. Some distance from the shaft the material changed in character and boulders predominated, the strata being that of a typical watersorted glacial deposit.

Lateral operations were begun by driving from the bottom of the shaft two side drifts, A, and one center drift, B, as shown in Fig. 1. The face of each drift was opened in one cut, using horizontal breastboards, and the sides between bents were supported in the same manner. Hay and straw were used as a backing to prevent flowage of sands. The posts and caps of drifts were either 8 in. x 8 in. or 8 in. x 10 in., with bents placed 2 ft. 10 in. center to center. Caps of side drifts were 7 ft. 4 in. and center drift caps were 9 ft. in length. The inner posts of side drifts were cut 8 ft., with the outer posts 7 ft., and the center drift posts were 6 ft. The roof was driven with poling boards, the boards being driven half way, the material excavated, and the boards driven home. A new bent was then erected, and the work carried on as before. Owing to the short distance between bents, there was little difficulty in supporting the sides. Two-inch poling boards were used.

On completion of the drifts, forms were erected and the concrete was placed to finished form. The concrete benches of side drifts were prepared to support the bearing surface of the roof shield. The bottom of the cross-piece of the shield passed 2 in. above the top of the side drift posts and approximately 1 ft. above the cap of the center drift. After the shield was in place the entire top heading was removed for a depth of about 32 in. and downward to the bottom of the shield cross-piece. Horizontal breastboards were used when necessary.

Tracks were carried at approximately the elevation of the top of the invert, allowing side-dump cars to be pushed in between the posts of the side and center drifts. The material excavated under the shield in the top heading was passed through the shield cross-piece into the cars. As the top heading was being cleaned up to allow the shield to be pushed ahead, the lower headings between the side and center drifts were removed, using breastboards with straw and hay.

Benches of the side and center drifts were prepared to carry the bearing surface of the erector for the metallic concrete forms. These forms were erected immediately back of the advancing shield, and the entire center wall C, side walls D, and umbrella E were blown in at one operation. There was little danger in the preceding method of excavation, as the face was the only area exposed, and the finished concrete was carried up close to the shield. As the shield advanced the drift posts were removed, and the invert F was advanced in sections. The tunnel was carried forward in a finished condition ready to be turned over for the rails.

The timber-driven tunnel face was carried through flowing sand, sand and loam, and gravel. The main and first point of attack is the top heading A, in Fig 2, with a width of 16 ft. 6 in. and a height of 8 ft. 6 in. If the material was fairly well consolidated, the entire face was taken out in one cut. If not, the face was divided into two equal areas, but carried very close to each other. If it was necessary to remove the face in two cuts, the upper was taken out in five vertical cuts (a, b, c, d and as shown in e, Fig. 3). Fig. 4 shows a section along the center line of tunnel in the top heading. The center cut (c) of the upper cut is made either 4 ft. or 6 ft., depending upon the material. The five cuts were made with breastboards and straw, and the lower part of the face is taken out in one cut. Side and center posts and caps are placed, and the face is ready for another cut. Twenty feet back of the face the center posts are removed, and the braces B. top pieces C, and uprights D are placed in position, taking the pressure on the still E and side posts of the drift. The supports B consist of 6-in. iron pipe filled with concrete.

Throughout the distance where the center posts are removed (for a distance of twenty feet), a trench is dug to subgrade, using vertical sheathing or 8 in. x 8 in. uprights, 5 ft. 4 in. center to center and boarded as side supports. This interval of twenty feet is maintained and the concrete center wall F is carried forward to the top of the trench and upward to the cap as a concrete post in place of the original center post. Back of the open trench the pipe braces B are then removed and the umbrella G is then blown in.

Simultaneously with excavation in the main face, the side drifts H are carried forward with the face held about 40 ft. back of the main face. In this drift the 12-in. x 12-in. wall plate J is laid. These side drafts are driven 3 ft. clear, with inside posts at the top, 3 ft. 6 in. at floor, and 5 ft. high. The two segments K are then excavated down to the top of the side drifts, and the arch timbers L are placed bearing against the cap of the first excavation and the wall plate in the side drift. The excavation for the segments K is carried on in a similar method to the first excavation, using breastboards and straw, with vertical sections varying with the material. Twenty feet back from the face of this excavation it is carried down to the level with the floor of the side drifts. In another twenty feet the cut is carried to the subgrade, side posts are placed, forms are erected, and the side walls concreted.

Examination for Sanitary Engineers.—The U. S. Civil Service Commission, Washington, D. C., has announced an open competition examination on July 6 for the positions of assistant sanitary engineer and junior railway engineer in the U. S. Public Health Service, at salaries of $3,225 and $2,320, respectively.

Freight Tunnel System as a Terminal Distribution Agency

At the recent spring meeting of the American Society of Mechanical Engineers at Chicago, the members of the Western Society of Engineers were [illegible] present some papers. Several papers were submitted by various members of the Engineers' Terminal Committee, and among these we quote one with the title given above, from a digest given the Western Society Journal. This paper was presented [illegible] and [illegible]

The Chicago Freight Subway System.—A freight transport system unique in modern terminal development exists underneath all of the principal downtown streets of Chicago on both sides of the river, which deserves special mention here. This network of tunnels is connected by elevator with all railroad stations, freight houses, important retail, wholesale and mail order houses, warehouses, coal, ash and disposal stations, and in short, with practically all the downtown industries of Chicago. The tunnel, while small in size, can handle from 70 to 95 per cent of L. C. L. freight tendered in the great majority of cases, and all freight from many of these connections. The tunnel serves four union L. C. L. stations and a large number of private commercial stations. Some with the shipping floors are at the tunnel level, requiring no tunnel elevators. At these union freight stations, miscellaneous freight for any number of destinations is received from a shipper on a single bill of lading, classified and routed to destination, the tunnel company acting as the terminal agent for the carrier road. The freight in these union stations is assembled continuously during the day in small standard cars of about 5.0 tons capacity and is hauled out in trains by electric locomotives and set off on siding at its destination, raised by elevator to the railroad's freight house floor to be loaded out in the day's outbound movement.

Thus the Chicago tunnel represents the best example today of a high class terminal freight forwarding machine in which the mechanical sorting of freight is done entirely by the carrier to the advantage of the shipper. It may be stated safely that, in ultimate limit of track capacity, the present tunnel could accommodate three to five times the present tonnage handled and with only moderate improvements in layout and elevator capacity at certain points. At present, the tunnel is handling approximately 1,800 tons of L. C. L. freight per day, or less than 10 per cent of the total outbound freight at the railroad freight houses. But it could possibly handle 10,000 tons per day. The capacity results from the tunnel layout, which is a single-track gridiron with trains routed in such a way that one street is northbound, the next southbound, etc., with numerous laterals and cross-overs to permit flexibility. These trains average 4.0 miles per hour, 8.0 miles maximum and they are able to traverse the Loop in any direction in the short space of 15 minutes. By systematic dispatching and with block signalling when found necessary, the Chicago Tunnel could function in a manner not generally appreciated at the present time.

To truck 2,000 tons of freight per day would probably require from 750 to 1,000 motor vehicle trips, if fully loaded, each day, or from 90 to 125 round trips per hour in an 8-hour day. Possibly the majority of these vehicles would not average more than three round trips per day, so that to move this tonnage on the street might actually require 250 to 350 vehicles. For 5,000 tons of freight and heavier loadings, 1,500 to 2,000 motor vehicle trips per day might be required, and for 10,000 tons possibly 3,000 trips or more, depending upon the system of motor transport used. Imagine the resulting condition of loop streets with such traffic.

For the above reasons, the conclusion is reached herein, against much argument to the contrary, that the Chicago tunnel must be regarded as an important element in local freight transportation, and one to be conserved, if for no other reason than to contribute to the relief of street congestion, for the tunnel is a sub-level freight handling street already constructed, and will permit the S. Water St. project to be developed more along the lines of a street improvement than as originally planned with railroad tracks and freight platforms in and along the lower level. The roadways should not be used for this purpose.

Why the Chicago Tunnel Is Not Put to Greater Use.—Considerable effort was expended in trying to discover why the Chicago tunnel is not now put to greater use. There are several reasons, none of which would seem to be a reasonable excuse for permitting such a unique transportation agency, involving 65 miles of tunnel line and $15,000,000 of investment, to fall into disuse. These reasons may be summarized as follows:

1. The tunnel is an independent enterprise with charges absorbed by the carriers; trucking charges are paid by the shipper.
2. Tunnel service appears somewhat more expensive than trucking, although the cost of delayed truck-time may reverse the situation.
3. Apparent greater delays in forwarding due to freight house congestion and hold-overs. Trucked shipments are often favored because of assistance rendered by drivers.
4. Large shippers may change from tunnel to truck service even for a fractional saving in charges.
5. Some bulky shipments cannot be handled—from 5 or 10 per cent in some cases to 30 per cent in others. The tunnel averages about 90 per cent availability.
6. Modern tendency to one-way business—for many large merchandisers use-carload inbound, L. C. L. outbound via tunnel. This is no defect of the tunnel.
7. Duplication of checking work and expense. It should be possible to avoid this in some reasonable manner and would be if the tunnel were a railroad agency.

A study of the existing Union tunnel freight stations shows the following results as applicable to designing of facilities recommended herein:

1. Platform space required—25 sq. ft. per ton per 10-hour day.
2. Service track required—One standing car per 10 tons handled per day.
3. Average load per car—1.4 tons general merchandise.
4. Team platform length—0.42 lin. ft. per ton per day.
5. Elevator capacity—30 round trips per hour now; 38 maximum when speeded up.
5. 1,000-ton station requires—25,000 sq. ft. floor space, 420 lin. ft. platform frontage, 1,260 ft. of standing tracks, 2 elevators, 90 merchandise cars.

Union freight station service is believed to be the answer to the charge sometimes made, of discrimination by the tunnel as between small and large shippers (assuming a classification of freight and charges levied on a class revenue producing basis rather than a flat tonnage basis). From the standpoint of the city of Chicago, no transportation agency could be more effective in solving the problem of existing street capacity and no effort should be spared to make this institution one of permanent success.

A High Power Weed Burner

The development of apparatus for burning weeds along a railroad track has been of especial interest to railway engineers in the South. As an instance of one of the latest developments the Railway Age describes a high power weed burner recently put in service on the Texas & Pacific Ry. which is capable of destroying vegetation for a distance of 10 ft. each side the center of the track while operated at a speed of 5 miles per hour. In addition to the weed burner car itself, the full complement of equipment required for this work includes a locomotive, an oil tank car, a water car, a camp car for employes and a caboose. The total cost of destroying vegetation with this equipment is said to be less than $5 per mile, including the consumption of 60 gal. of fuel oil per mile by the locomotive and the weed burner.

The description states that the burner was constructed on the principle of a direct application of heat at a temperature of 1,400 to 1,500° F., and experience has developed that this may be done with safety. The heat is blown upon the vegetation beneath a hood 38 ft. long suspended over the track, giving a length of contact sufficient to destroy vegetation while the burner is moving 5 miles per hour.

The heat is developed by the efficient combustion of fuel oil, combined with the correct quantity of air applied by forced draft, the combustion taking place in a furnace lined with refractory materials. The temperature of the furnace gases is reduced to safe limits for application to the track by the further admixture of air in suitable quantities. A particularly complete arrangement has been worked out for the mechanical handling of dampers, wings, hoods, etc., so that the process is thoroughly under the control of the operator.

A Graphical Study of Fares and Short-Haul Traffic

Mr. E. A. Roberts, writing in the Electric Railway Journal, has made an interesting study of fares and short-haul traffic on electric lines. The following is taken from his article:

It is generally recognized that the rate of fare charged by a city street railway and the headway of service have a marked effect on that part of the company's gross revenue that is received from the short-haul riders. The experience of virtually all companies which have raised their fares is that some of the short-haul passengers become pedestrians with each increment of fare, for which an allowance must be made in predicting the revenue that will be received from higher rates of fare.

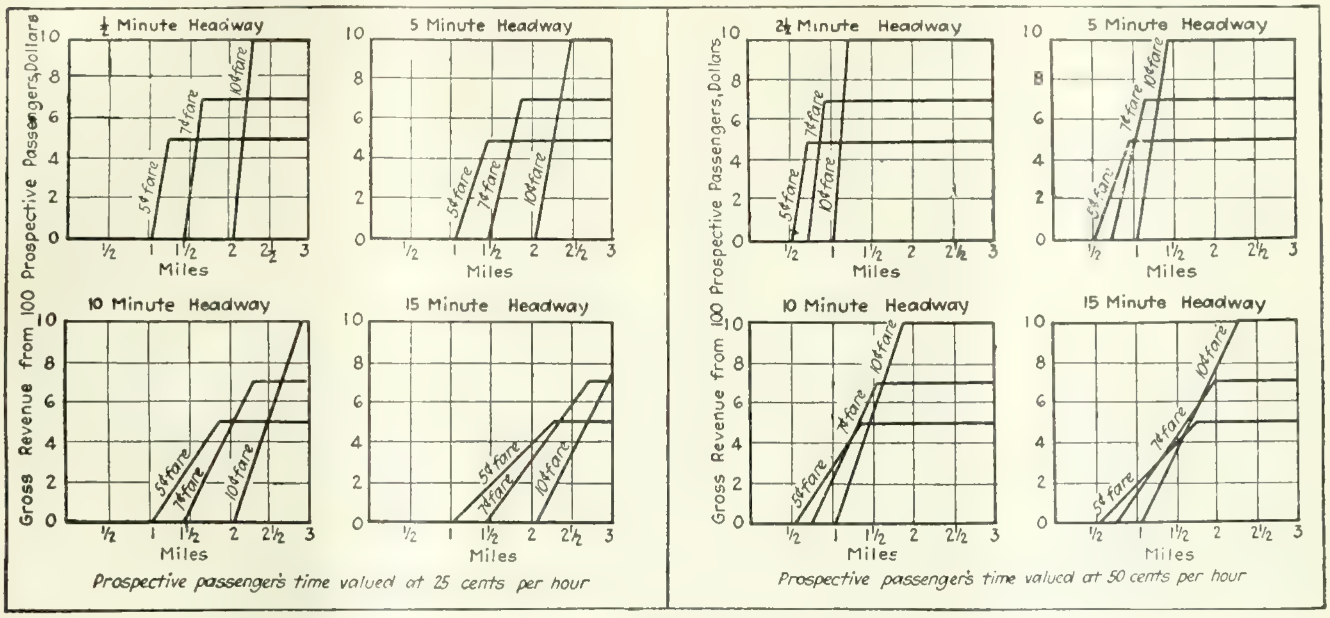
The first principle to take into account is the value of the short-haul rider's time. He will make a trip on a conveyance only when by so doing he saves enough time to compensate for the fare paid. If he cannot do this, he will walk or at least fail to patronize the street cars. To illustrate, if a man's time is considered as being worth 50 ct. an hour, and the street car fare is 7 ct., this man in using the cars must save 7 cts.' worth of time, which would be 8.4 minutes over the time required for walking.

The accompanying charts have been prepared to show the gross revenue receivable from each 100 persons who would use the street cars for rides up to 3 miles in length if it resulted in a saving of time sufficient to compensate for the fare charged. Three rates of fare, 5, 7 and 10 ct., four different car headways, 2½, 5, 10 and 15 minutes, and two values of the car rider's time, 25 and 50 ct. per hour are assumed.

The case of 100 persons desiring to take a street car ride of 2¼ miles on a line with a ten-minute headway will first be taken and the value of these people's time will be assumed at 25 ct. per hour, and that they are capable of walking at the army rate of speed, 5 ft. per second. The average speed of the street cars will be considered at 10 m.p.h. To walk the 2¼ miles will take 39.6 minutes, while to ride will require 13½ minutes, so that the person who can board a car without waiting will save 26.1 minutes, while the person who has to wait the whole headway, ten minutes, will save 16.1 minutes.

On a 5-ct. fare basis the price paid for the ride is equivalent in value to 12 minutes of the passenger's time. In this case the entire 100 people should be attracted to the street car service because of the time saving. With a 7-ct. fare and a 10-minute headway, 16.8 minutes must be saved to compensate for the price of a ride. The man who can board a car immediately can afford to ride, but he who just misses one will be 0.7 minute or 42 seconds better off by walking. If the 100 people are assumed as arriving at the stopping place at regular intervals, say six seconds apart, just seven of them will arrive during the 42 seconds following the departure of a car, and consequently will fail to save time by riding on the street car. The remaining 93 will profit so far as time is concerned by riding, and at 7 ct. each will yield $6.51. With a 10-ct. fare, 24 minutes is required to offset the expense of riding. Direct connection will save 2.1 minutes over the walking time, but the man who has to wait 10 minutes for a car would be much better off by walking. Only 21 per cent of the people will in this case find it a satisfactory financial transaction to pay the 10-ct. fare.

The point at which a sloping line in the chart starts upward indicates the minimum ride which a person is justified in taking provided he just connects with a car, which would be of course regardless of the frequency of service. The top point of the sloping line shows the minimum ride the person who waits the full interval between cars is warranted in taking. Stated in other words, the top point indicates the maximum distance a person who just misses a car would be justified in walking. The slope of the line bears a direct relation to the headway and is a measure of the doubtful zone in which a person might either walk or ride. The more frequent the service, the shorter should be the walking radius of possible riders.



Diagrams Showing Comparative Walking Distances for Various Headways When Base Fares Are Fixed at 5, 7 or 10 Ct. and Time Is Valued at 25 or 50 Ct. Per Hour.

16,000-Ton Train Loads

The Virginian Ry. has as its principal traffic the hauling of coal to tidewater, and in the efficient handling of this one-way traffic, some of the most powerful engines and largest cars yet built have been used for several years past.

One of the problems met with in the increasing traffic is the matter of handling safely on the long down grades these enormously heavy trains. The Westinghouse Air Brake Co. has been called upon to design braking equipment suitable for the control of trains of 16,000 gross tons on down grades of 1.5 per cent and 10 to 12 miles in length. The special factors entering into this problem are:

a. To provide a sufficient degree of braking power for the loaded trains.

b. To provide only such braking power as needed for the empty train of less than one-third the weight.

c. To provide the very greatly increased braking power on loaded train without appreciable increase in consumption of air.

d. To so devise the equipment that in the event of excessive leakage in brake cylinder, the effect will be on the individual car and not the rest of the train.

The Railway Review, from which the above is taken, states that arrangements have been made to demonstrate the successful handling of loaded trains of 16,000 gross tons on the steep grades mentioned above and also on level districts.

Bonuses on Construction Work

In Engineering and Contracting for Jan. 28, 1920, there appeared an article entitled "Application of Wage Bonus Plan to Construction Operations." The plan is based upon the establishment of a standard time for the performance of a certain amount of work, and when this set task has been accomplished, the payment of a substantial bonus for additional work done. The article describes how the plan was applied to hand excavation on a railroad cut, carpenter and concrete work on bridges. In each case those in charge of the work decided "on the method and a number of men who could work to advantage, then set the time standard." There was thus determined the number of man-days in which the job should be done. The efficiency of the working party was determined by dividing this number by the actual number of man-days in which the job was done, and a bonus paid if this efficiency was 75 per cent or higher. The following table shows the per cent of bonus paid for various efficiencies:

Efficiency per cent.	Bonus per cent.	Efficiency per cent.	Bonus per cent.
[illegible]	1.0	90	10
[illegible]	1.6	91	11
[illegible]	2.0	[illegible]	12
[illegible]	2.4	[illegible]	13
79	2.8	[illegible]	14
[illegible]	3.3	[illegible]	15
[illegible]	3.8	96	16
[illegible]	4.3	[illegible]	17
[illegible]	5.0	[illegible]	18
[illegible]	5.5	[illegible]	19
[illegible]	6.0	100	20
[illegible]	7.0	[illegible]	21
[illegible]	7.6	[illegible]	22
[illegible]	8.4	103	23
[illegible]	9.2	[illegible]	25

In the current issue of the Military Engineer, Maj. J. R. Slattery, Corps of Engineers, U. S. Army, comments on the article and offers suggestions on the application of a bonus plan to dredging operations. We quote from his article as follows:

The plan described appears a most excellent one, but there are some irregularities in the increments in percentage of bonus to be paid that do not seem quite reasonable: for example, for an increase in efficiency from 74 per cent to 75 per cent, 1 per cent bonus is paid, but for the next 1 per cent increase in efficiency, the bonus increment is only .6 per cent, while for the next 1 per cent (76 per cent to 77 per cent), the bonus increment is only .4 per cent. Again the increment in bonus corresponding to an increase in efficiency from 85 to 86 per cent is 1 per cent, whereas it is only .5 per cent and .6 per cent, respectively, for increases in efficiencies from 84 to 85 per cent, and 86 to 87 per cent. A more logical table would seem to be the following:

Efficiency per cent.	Bonus per cent.	Efficiency per cent.	Bonus per cent.
75	0.	[illegible]	10
[illegible]	0.4	91	11
[illegible]	1.0	92	12
[illegible]	1.6	[illegible]	13
[illegible]	2.2	94	14
[illegible]	2.8	95	15
[illegible]	3.4	96	16
[illegible]	4.0	[illegible]	17
[illegible]	4.6	98	18
[illegible]	5.2	99	19
[illegible]	6.0	100	20
[illegible]	6.8	[illegible]	21
[illegible]	7.6	102	22
[illegible]	8.4	103	23
[illegible]	9.2	[illegible]	24
		[illegible]	25

Determination of Bonus for Dredging Operations. The writer has in years past discussed the bonus plan with many contractors and has found them almost universally of the belief that the payment of bonuses promoted the efficiency of work. It is more difficult to find a satisfactory plan for payment of bonuses to government employes than to contractors' employes, but it is believed that the government would benefit greatly by adopting the bonus plan, wherever a reasonable basis for the payment of the same can be determined. In the case of dredging it is thought that a basis could be determined, for any given plant, as follows: Assume that a dredge works at 100 per cent efficiency when it works 20 hours out of every 24. For any given job a reasonably accurate estimate can be made as to about what yardage should be removed per month if the dredge actually worked at 100 per cent efficiency as defined above.

In any given locality the number of months of the year during which actual dredging operations can be carried on is known within close limits. Call this "n" months. The actual cost of dredging operations for the year includes not only the expenses incurred during these "n" months, but likewise the expenditures for care of plant and annual overhauling during the other months of the year. The true cost of any month's dredging, therefore, is equal to the actual operating expense (including cost of repairs, ordinary and extraordinary, during that month), plus 1/n of the cost of annual overhauling and care of plant during the lay-up season. At any given time, it is possible to estimate accurately an amount which should cover the monthly cost of operation (exclusive of repairs), and to approximate amounts which should cover cost of monthly repairs, ordinary and extraordinary, and cost of annual overhauling and care of plant during the lay-up season. From these figures there can be determined a monthly operating cost which should not be exceeded by 1/n of the total operating cost for a year, and if this monthly cost be divided by the number of yards which it is calculated the dredge should remove when working at 100 per cent efficiency there will result a unit cost that could be used as a basis for determining the efficiency of dredge operation during any month. The per cent of efficiency would be obtained by dividing this basic unit cost by the actual unit cost for the month calculated as follows:

$$\text{Unit cost for month} = \left[\text{Total operating cost per month, including cost of repairs} + \frac{\text{Cost of annual overhauling that year}}{n} + \frac{\text{Cost of care of plant during lay-up}}{n}\right] \div \text{Output for month.}$$

This may possibly appear somewhat complicated, but it is believed that if a study is made of operating costs of any given piece of plant, it will be found that the quantities involved are determined without difficulty and are reasonably convincing. It is considered essential to introduce a factor representing cost of repairs into the basic cost for use in determining efficiency, in order to guard against the danger of a crew's endeavoring to obtain output at the expense of proper care of machinery.

There might be some difficulty in determining the output to the satisfaction of all concerned, but it is believed that if the output was determined by a survey party having no interest in the bonus, and this survey party was in charge of a capable man, there would be little chance of collusion between dredge crew and survey party.

It is probable that most government engineers, who have had to do with the handling of labor during the past year have been impressed with the desirability of finding some way of stimulating labor's interest in work, and have found that neither increases in pay nor discharges accomplish that end. Perhaps an intelligent bonus system will meet the needs.

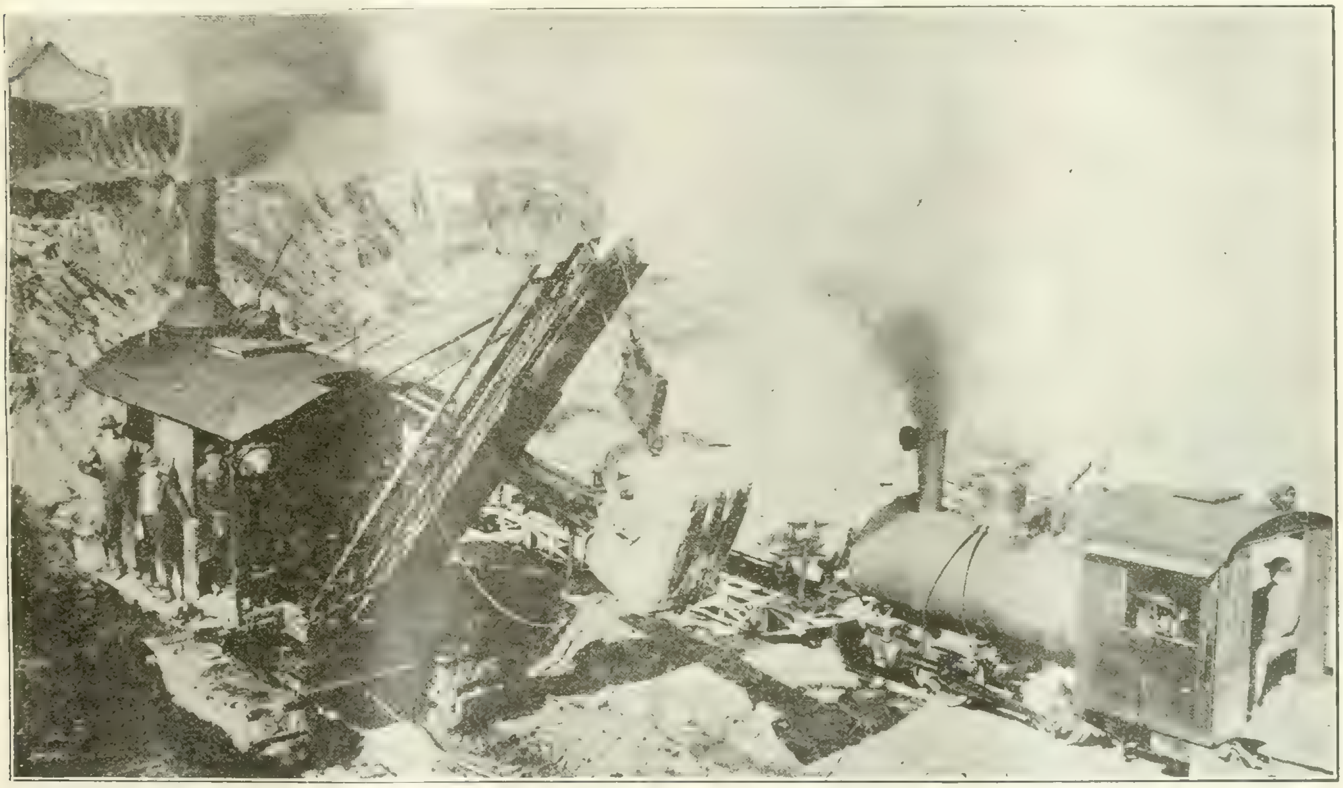
New York's Public Utility Commission and Politics

New York's Governor in the few months he has been in Albany has achieved much. He has insisted on economy in state expenditures and by consolidations and pruning has applied the acid test of political incompetency and waste. In these respects he has shown himself an excellent executive and an unusual governor. Naturally, in haste to fulfill pre-election promises, performance, however good, often falls short of intention. On the whole, the Public Service Commission law as revised is good, but the appointees so far must be accepted on faith. Evidently experience in public utility affairs did not count in their preferment. But a body composed of five Republicans appointed for a term of ten years at a salary of $15,000 a year and removable only by impeachment or legislation seems to us to offer an excellent opportunity for Democrats when they come into power to legislate the commission out of office and appoint five of their political faith. Thus the commission is thrust wholly into politics and all that that means. The only fortunate part of the affair is that the personnel which actually deals with public utilities is virtually unchanged.—Editorial in Electrical World.

Locomotive Headlight Turbines Used for Operating Floodlights on Steam Shovels

Application of locomotive headlight turbines for operating flood and headlights on steam shovels and locomotives engaged in night work has recently been tried with success by the Mandle Clay Mining Co. of Whitlock, Tenn. This company's equipment consists of two steam shovels and three shifting locomotives, and on each of the shovels it has mounted two General Electric L-3 light projectors and 32 volt, 500 watt headlight turbines of the same type used for locomotive headlights. The switching engines carry a turbine and two headlights, one in front, and the other on the cab.

The larger of the two shovels has the floodlights mounted so as to directly illuminate the point at which the bucket is operating, the headlight on the shifting engine serving to aid in unloading into the car. The floodlights on the smaller shovel which is of the revolving type are so placed that they not only illuminate the bucket's field of operation, but, when the shovel is swinging around for unloading, they light up the car. The shovels carry 110 lb. boiler pressure, which furnishes power for the turbine which besides the two floodlights carries three 25 watt lamps in the interior of the cab to aid the operator and fireman. There is also sufficient capacity for two more floodlights if desired.



Turbo-Generators, Headlights and Flood Lighting Projectors on Steam Shovel and Locomotive of Middle Clay Mining Co.

The shifting locomotives carry 150 lb. boiler pressure, and are equipped with one 500 watt turbine for the operation of two h-3 mine type headlights with 75 watt lamps. Where greater illumination is necessary it is possible to apply headlights of as large as 250 watts capacity, such as are used on railroad locomotives.

The turbines on both shovels and locomotives are of the standard type built by the General Electric Co. for locomotive headlights. They are equipped with low pressure valves and nozzles carrying rated voltage and capacity between 70 and 170 lb. boiler pressure with a water rate of approximately 110 lb. per hour.

An Engineer's Tribute to the Pure Scientist.—"The engineer of today is the right-hand man of the scientist in transforming thoughts into service."—From the address on June 8 of Charles H. MacDowell, incoming president of the Western Society of Engineers.

Working a Mine at a Depth of 7,000 Ft.

In a paper presented before the British Institution of Mining and Metallurgy Mr. H. E. Clifford describes the scheme that has been adopted for working the City Deep mine at a depth of 7,000 ft. The mine is now being operated from two vertical rectangular 7-compartment shafts 4,000 ft. apart, 3,300 and 4,000 ft. deep, respectively. From the bottom of these shafts extend two 5-compartment inclines which lie under the reef and are connected with it by cross-cuts at each level. The west shaft has reached the 20th level, and the east the 18th level. The vertical depth of the 20th level is 4,950 ft.

The inclines will soon reach the vertical depth at which troubles with rock pressure are likely to become serious, and their length will have reached the economic limit. There will thus remain an area equal to about one-third of the property which is not provided for by present appliances, and the scheme adopted in solution of the problem of exploiting it consists in sinking a vertical shaft of circular section, 7,000 ft. deep, in two stages of 4,500 ft. and 2,500 ft.

The upper section will stop at the 17th level, where it will make connection with the two incline shafts, and the reef will be attacked from the lower section of the shaft by cross-cuts at each level. The shaft is 20 ft. in diameter in the clear, and is fitted with concrete rings spaced at 10 ft. vertical intervals. The rings are each 18 in. deep by 15 in. wide, and their function is to provide adequate fastenings for the shaft-guides, pipes, cables, etc., and also to afford a foundation for any form of lining that may be found necessary. The capacity required of the shaft is 2,000 tons of ore per 24 hours, plus all the men and materials necessary for this output.

The cage is to be 15½ by 5¼ ft., with two decks, and will be made of alloy steel, as the saving in weigh thereby effected will materially increase the working life of the winding ropes, diminish the consumption of power, and more than compensate for the additional cost. An existing double inlet Sirocco fan, 154 in. in diameter, with a capacity of 420,000 cu. ft per min. at 2½ in. water gage, is now being run at only about half its capacity, and the surplus cooling power will be sufficient to offset the growing extension of the mine for a long time to come. Of the 300,000 cu. ft. that will be made to travel through the new shaft, 75,000 cu. ft. will be required to cool the electric winder and converter sets at the 17th level station, the remainder being directed through the lower shaft to the bottom workings.

Some Things an Engineer Should Know About Banking

The engineer should keep in close touch with business and banking policies. The enterprise in which he may take part as a technical expert may be materially affected by subtle economic trends. He should particularly understand those influences growing out of the expansion and contraction of bank credit. These points and many others that an engineer should be familiar with are discussed by Edmund D. Fisher, Vice-President, Bank of Detroit, in a recent issue of The Michigan Technic, from which we have taken the matter that follows.

Successful Business Men Have Been Large Borrowers.

Debt has been a stumbling block to progress in the career of many men, yet the most successful business men have usually been large borrowers during a period of their progress. But, usually, wise borrowers—not too much in relation to their own capital, not with too great a margin of risk, not too much for the energy and capacity so necessary to make the borrowed money bear fruit and provide the means for repayment. A loan for a well-managed and productive enterprise is of value to the entire community. Banking policy applied along such lines makes a nation wealthy. A loan used for speculative purposes, on the other hand, developing no means of repayment, may tend to divert the borrowers or others from productive work and to make the nation poor. Borrowed money frequently means borrowed trouble to the individual, unless the loan has some legitimate economic purpose. A mortgage which aids a thrifty man to buy a home may be a blessing; the mortgage, when it means running behind and is used to pay the debts of speculation and waste, may prove a curse.

No unwise loan, in the individual case, has any particular effect from a broad economic standpoint, but a large volume of such loans have frequently had the effect, in American finance, of swinging the nation from prosperity to depression. The individual borrower is sometimes very angry when his banker, in view of certain general conditions, declines to loan on collateral security, stocks and bonds. He naturally believes there is no safer type of loan for the bank, if properly margined, and has no patience to listen to a dissertation on the relation between fixed and fluid credit. He wants the money.

Fixed and Fluid Credit.—The difference in character between fixed and fluid credit makes it very necessary for both bankers and borrowers to thoroughly understand the relations between the two forms, and the ultimate effect of their use as instruments of banking upon all business enterprise, more particularly upon the price fabric of the country and to all forms of new enterprise.

Credit advances (loans) should be considered both from the standpoint of the possible relations to the bank making the loans, as well as the broad influence upon the business world of such loans in volume, made by many banks.

Correct banking practice is based upon the assumption that depositors must always be paid upon demand (demand deposits), unless their money has been left on deposit for a definite period. The bank, therefore, must be in a position to meet all demands. Experience shows that all depositors do not demand the return of all their money at one time. If they did, banks could not make loans at all, could not pay interest on deposits, and would be, in effect, merely safe deposit companies for the safe-keeping of money. With the reasonable assurance that money will remain on deposit, in the aggregate, for sufficient time and in sufficient volume, banks loan their funds to their customers in various forms. The commercial banks loan mainly to corporations or individual borrowers who, in advance, show a reasonable ability to pay off the loan in a reasonable time (fluid credit). Thus, if depositors should want their money, the banks have constantly maturing loans which automatically provide the money for the purpose, or the credits can be rediscounted by the local Federal Reserve Bank. Loans are thus made by banks to mature in 30, 60, 90 days, or longer, dependent upon the needs of the borrower and the time of his probable receipt of funds to pay his note when due.

The well-managed bank has a large proportion of its funds maturing day by day, within a six months' period, including loans not only due to be paid by its own customers (discounts), but also by responsible concerns in various parts of the country, who do not expect a renewal of the loans when due (commercial paper).

A portion of bank deposits are either actually left for a period under an agreement (time deposits), or are, in the aggregate, never withdrawn. It, therefore, becomes possible for banks also to loan a portion of their deposits, as well as their own capital and surplus, in the form of collateral loans and in the purchase of high-grade investments.

In the case of savings banks or banks with savings departments, loans are made on bonds and mortgages (all fixed credits). Mortgages usually run from one to three years, and it may be a hardship for the borrower to pay the entire amount when due. There has thus developed the practice of planning partial payments during the entire life of the loan, not only developing the habit of saving on the part of the borrower, but also giving something of a **fluid** quality to the loan.

Collateral loans, unless the supporting securities are due to be paid, do not, in their very nature, provide any means of repayment, except through a sale of securities. Thus it is that banks are sometimes compelled to refuse to make such loans, in order to preserve the appropriate relations between the loans based on fixed and fluid credit.

Effect of Economic Trends in Business on Bank Policy.—Banking policy is also controlled by the economic trends in business and financial life, as loans in volume, made or called by many banks, have a direct bearing on inflation or deflation, the price of securities and the price of commodities. The proceeds of loans are credited to the deposit accounts of the borrowers, and deposits, in their increase or decrease, affect the spending power of the people just as truly as does the increase or decrease of gold or silver currency, or the paper money issued by governments or banks. A growing spending power increases prices; a lessening spending power reduces prices.

The basis of credit may thus be actual value of a permanent nature, or actual value of a fluid or consumable kind. If money is loaned, it may command either type of value. It may promote inflation through increase in prices by the new spending power of the borrowers in non-productive enterprise and waste; it may, on the other hand, if properly applied, stimulate the production of new wealth and ultimately tend to reduce prices.

It is often the intention of the borrower on collateral security to buy more stocks or bonds with the proceeds of his loan, thus adding to the spending power of a period of inflation and serving no economic purpose. Such tendencies, in the aggregate, ultimately strain credit, curtail the lending power of banks, and are first expressed in a movement to "call loans" in the great money centers. The inevitable result is the sale of securities in volume to pay loans, with the consequent depreciation in prices.

Fluid credit, on the other hand, usually based upon an actual transaction which will return the money to pay the original debt, bears a proper price relation to actual business and creates a stable medium of exchange without the elements of inflation.

Deposit Currency.—Recent banking practice has developed large volumes of **deposit currency** (checks), based upon fixed forms of credit, and the use of this currency has disturbed price relations. As there is ability under ordinary banking conditions, to exchange deposit credit for actual money, it is evident that in using the check drawn on these deposits, as well as money, we have a composite medium of exchange. Through the **loan, deposit and check** process of modern banking, the proceeds of loans on shares of corporate business, on government bonds, and on dwelling-houses and other evidences of fixed value, are added to the volume of basic currency. This has naturally tended to "bull" the market —either the stock market, the bond market, or the commodity market, as the case may be.

The vast growth of loans since the beginning of the century, manufacturing deposit currency mainly through loans on the collateral security of new corporate enterprises, probably has been an important element in price inflation. Business, in the aggregate, develops its own inequalities—varying profits, varying losses, under-production and over-production —so that, in connection with an unscientific credit relation, readjustments are inevitably necessary. Under the strain of a readjustment period and its forced liquidation, fluid credit stands the test and the bank collects one hundred cents on the dollar. Fixed credit, on the other hand, represented by securities, is notoriously unstable and investments have to be sacrificed to meet the obligations of fluid credit; hence the ups and downs of the stock market. In this process, banks do not lose as a rule, but the borrowers do. Out of these conditions, well-known to men of experience, comes the bank's policy in relation to various types of loans.

Why Making Loans Upon Fluid Credit Is Best Banking Policy.—Paul M. Warburg, in his "Discount System in Europe," gives this clear explanation why to make loans upon fluid credit is regarded as the best banking practice:

"As a majority of discounts represents goods in process of production, or on the way to consumption, liquidation with them primarily expresses itself by a falling off in new production, while the consumer, on the other hand, cannot stop consuming and must, therefore, continue to pay. The brunt (of payment) is thus borne by the whole nation and adjustment follows without violent convulsion."

It is thus evident that the lack of scientific relation between fixed and fluid credit in banking practice brings recurring periods of extreme inflation or deflation, with disastrous effects upon all forms of business enterprise.

The actual exchange of fixed credit, or fixed capital, such as bonds or real estate, is very properly effected through the medium of fluid capital. The man who buys a house has the free capital to do it. The seller re-deposits the amount, and its use as fluid capital is not destroyed. The ownership of the fixed capital has merely been transferred. The control of the fluid capital has also been transferred. A large number of such transactions, as during a period of real estate speculation, particularly with a diversion of some of the fluid capital to real estate loans and construction work, tends to divert fluid capital to fixed forms. This is also true during periods of stock speculation coincident with increasing loans on an advancing market. Thus it is that many such banking transactions, innocent enough in the individual case, as has been pointed out, are harmful in the aggregate. Such uses of fluid credit not only disturb the business and investment markets through the inflation of value and the increase of prices, but the actual labor of men, through the directing power of the dollar, is frequently diverted from productive to non-productive enterprises. One of the great panics of the last century grew out of the use of too much liquid capital in railroad building.

It has been shown that under our present form of banking, fixed credit may be transmitted into the dollar of exchange and in volume develop serious inflation, with the resultant increase in security and commodity prices. This reacts on the value of even gilt-edge securities, as high commodity prices bring diminished purchasing power from the returns of fixed interest. Thus the entire price problem becomes a vital one to the business world, because of its relation, indirect but potent, to the stability of investment values. It is not merely the question of the value of the individual bond and its ultimate payment, but the effect of the broad movements of security and commodity values upon the surplus account of the bank and the merchant.

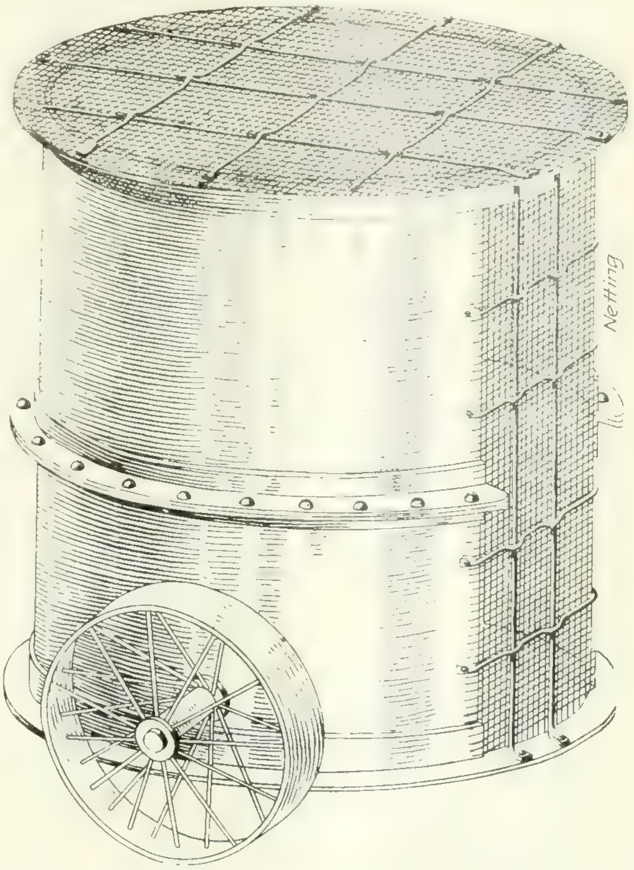
All of this means that those active in all forms of enterprise, cannot afford to be indifferent to present conditions and the development of a sound credit situation. When this has been accomplished, there will come into existence a new credit system which will ultimately serve all the people by the establishment of more equitable banking relations. This will give a fairer opportunity for the development of business enterprise and a consequent production of more wealth, with its greater investment ability. It will minimize those subtle, yet actual, losses that come to so many through the insidious price movemens which, in a large measure, result from the confusion of fixed and fluid credits.

Examinations for Dust Explosion Prevention Engineers.—The U. S. Civil Service Commission, Washington, D. C., has announced open competitive examinations for the following positions in the Bureau of Chemistry, Department of Agriculture, Washington: Associate dust explosion prevention engineer, $2,500 to $3,600 a year; assistant dust explosion prevention engineer, $1,800 to $2,500 a year; junior dust explosion prevention engineer, $1,440 to $1,800 a year; associate development engineer, $2,500 to $3,600 a year; assistant development engineer, $1,800 to $2,500 a year; junior development engineer, $1,400 to $1,800 a year. Applications will be received until June 21.

A Safeguard for Surface Blasting

In putting through an approach to the Mesabi Mountain mine of the Oliver Iron Mining Co., at Virginia, Minn., the "tank" shown below was used to prevent damage from frozen chunks of earth, small boulders and dirt thrown up by the surface blasts. The following account of the device is abstracted from the Engineering and Mining Journal:

The ground was composed principally of glacial till, which ordinarily offers little resistance to the steam shovel. Most of the work, however, was done in the winter, under extreme temperature conditions, and as the frost extended to a depth of 6 ft. in places, it was necessary to drill blasting holes ahead of the shovel. Before blasting the tank was rolled over the holes.



"Tank" for Safeguarding Surface Blasting.

The tank, which was mounted on iron wheels, was made from one of the blasting or shelter houses used in open pits on the Mesabi Range to provide safety for the men. They are circular in shape, made of steel plate, provided with a conical roof, and are ordinarily placed at various points so that workmen may take refuge in them during blasting. To convert the shelter into a blasting tank the conical top was removed, ¼-in. mesh iron screen substituted for it and 1½-in. bars were bolted to the outer rim. Similar bars, threaded and bolted on the outside, were placed about a third of the way down from the top, these serving to reinforce the tank. Screening, also reinforced, was placed over the entrance of the former shelter.

Government Ownership and Service to Public.—Although at one time sympathetic toward government ownership, I am certain, after a number of years in government service, that no community can receive the industrial service to which it is entitled under municipal or governmental management. It is not humanly possible to obtain the same effort or interest from managers or men employed in industrial government service that exists in competitive private ownership, and as a result, if the advocates of government ownership investigate the facts carefully and impartially, they will find that government operation in industrial service is a flat failure from a "service to the public" standpoint. This is true not only in America but it is a proved fact throughout the world.—Edward N. Hurley, in address April 29 before the Chamber of Commerce of the United States.

Intensive Development of City Freight Terminals

The following is taken from a paper read by Mr. E. J. Noonan, Engineer Chicago Terminal Commission, before the recent joint meeting of the American Society of Mechanical Engineers and the Western Society of Engineers, at Chicago:

In the past few years students of railroad questions have given considerable thought to the possibilities of economics in the operation of city freight terminals and a great deal of this thought has taken form in the suggestion for a more intensive use of the valuable real estate occupied by the railroads near the business centers of our principal American cities.

In the city of Chicago, in the district immediately south of the central business district, the property used for railroad freight house purposes has been estimated to have an average value of $20 per square foot.

In this same district, on the basis of the area used per car standing capacity, figuring interest at 6 per cent, the interest charge on the property used would amount to $1.20 per ton.

In this same district at pre-war rates the amount paid for supervision and labor in the operation of the freight houses amounted to about 50 ct. per ton, so that if interest on the value of land were charged directly against freight house operation it would amount to double the total labor charge.

Relative Economy of Single and Double Level Freight Houses.—It has been this condition that has caused the advocacy in Chicago of the two-level type of freight house, requiring only half the land.

The single-level type of freight house with its accompanying tracks can be provided for about $2 per square foot, and the double-level type for about $5.

With these figures as a basis the relative economy, so far as interest on land used is concerned, is:

	Assumed value of land.			
Per square foot	$5.00	$10.00	$15.00	$20.00
Interest charge per ton at 6 per cent single level	.42	.72	1.02	1.32
Interest charge per ton at 6 per cent double level	.30	.45	.60	.75
Saving cents per ton	$0.12	$0.27	$0.42	$0.57

There are possible economies in connection with the operation of multiple-level freight stations which still further favor this type, but these fall under the subject of operation and it is the purpose herein to cover only those economies connected with land usage.

Examples of Multiple Level Freight Stations.—There are examples of multiple-level freight stations in Philadelphia, Pittsburgh, Minneapolis and St. Louis, but in all of these cases the type was adopted primarily on account of topographic conditions and not because of the more economic use of land.

In the West Side terminal area in Chicago, while the land area occupied is practically level, the necessity of carrying streets through the area on viaducts to connect with bridges over the Chicago River directed attention to the possibility of economies in multiple-level development.

The Pennsylvania R. R. freight house in this West Side area is of the two-level type with storage space above and has been in operation for several years. A portion of the Chicago & Alton R. R. freight house in the same area, also of the two-level type, has just been completed and put in operation, and there is under construction another portion in which there will be several floors for general office and warehouse purposes. Construction has been started on the Burlington freight house, in the same area, which is also of the two-level type with warehousing space above.

The railroad occupied territory in the West Side area of Chicago is separated from the central business district by the Chicago River. The river and the railroad occupied property together forming an effective barrier to the extension of the central business district continuously in a western direction, so that this property is naturally segregated with its own distinctive features and the treatment is more or less specific, and probably not generally applicable to [illegible]

A Plan for Treatment of Railroad Occupied Territory in Chicago.—The railroad occupied territory south of the central business district of Chicago is in a somewhat different situation. Here there are no natural barriers to the extension of the business district southward, the only barrier being the presence of railroad occupation.

The opportunity is therefore presented of developing a treatment of this property in a way that will permit of its most economic use and at the same time remove the barrier to the expansion of the business district.

As has been shown, there is a precedent for the adoption of the two-level type freight stations where land values are sufficiently high. The construction of hotels, apartment houses and other high-grade structures over the property occupied by the tracks of the New York Central R. R. at New York City furnish a precedent for the full use of air rights on valuable real estate occupied by railroads. In the treatment of the railroad occupied territory south of the central business district in Chicago the effort should be made to create a character of improvement that would permit of a commercial development super-imposed on the railroad development and extending to such heights found to be economically correct.

This property is adjacent to the south branch of the river and incidental to the development would be the straightening of this river so that it would be parallel with the general direction of the north and south streets and make possible the opening of additional thoroughfares through the district.

Through the railroad district there could then be constructed streets extending north and south and east and west carried on viaducts on substantially the same level as the floor of the river bridges.

Team traffic to the freight house would use the driveways on the viaduct level located between the north and south streets, and covering the railroad freight houses would be a commercial development which would have frontage on the north and south streets independent of the access to the freight houses.

We would thus have an artificial plateau created in an otherwise level area with a railroad and commercial development—each independent of the other—and having each its own method of access.

In the particular district referred to in Chicago, the area treated would have a width of about ¼ mile and a length of about ¾ mile. The space developed over the railroads would be in the form of several units. These units could be interconnected by tunnels so that all warehousing space in the district would have access for inbound and outbound shipments to every track of every railroad having its facilities in this district.

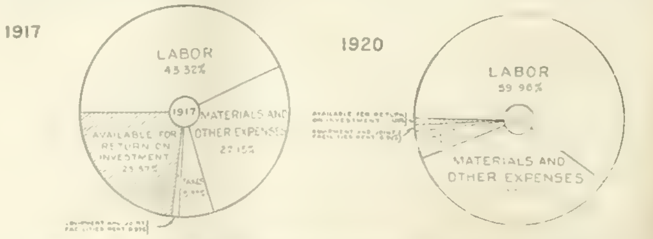
The saving drayage costs alone would be an important item and the removal of this drayage from the city streets would be a very great benefit to the city—particularly as the streets in the downtown district have already reached almost the limit of congestion.

On the basis of present rentals for loft buildings in the same general vicinity, the air right development would yield a net return sufficient to pay interest charges on the construction cost of both the air right and railroad development.

The proposition of more intensive use of valuable real estate held by railroads in large cities is economically sound; will be an important factor in financing improvements in city freight terminals and is demanded from the standpoint of civic betterment.

The Railway Dollar

The two diagrams reproduced below from the Railway Review are from figures given by Mr. Julius Kruttschnitt, Chairman of Executive Committee, So. Pac. Ry., in an address to the New Orleans Association of Commerce last March.



How the Railway Dollar Was Spent in 1917 and 1920.

Methods for Increasing Efficiency of Maintenance of Way Employees

As a means for increasing the efficiency of those employed in minor positions on the railroads it was suggested in the report of the Committee on Economics of Railway Operation of the American Railway Engineers Association, presented at the last annual convention of the association, that comparisons of the effective work of individuals or groups of individuals or employees be tabulated and published; these comparisons to be of subjects in which an employee is engaged. The purpose of these comparisons is to stimulate friendly rivalry which may be developed in practically every line of railroad work.

These comparisons should be discussed with the employee, in groups of his fellow-workmen, for the purpose of securing their criticism and advice, recognizing their knowledge and insuring their interest. Men are interested in their own line of work; in fact, they are inclined to think all other lines are subordinate to theirs. This idea should not be discouraged.

While the final result to be secured is the cost, the units for comparison should be those in which the employee thinks; for instance, if a section foreman is asked about the number of ties he can put in, he will reply, so many per hour or per day; or a locomotive fireman will keep tally on the number of scoops of coal he uses on a run for his comparisons.

The data collected should be published at least once per month, in some instances oftener. During the season when the subject under discussion is being actively engaged in, such as insertion of ties, reports should be made every week. The reports should also be kept up to date, and if the data are not furnished by the employee promptly, inquiry should be made to ascertain the reason for the delay. If this is not done, the employee will think it has been forgotten, interest will die out, and soon there will be no records.

Methods for keeping the records should be published to prevent misunderstandings, and to insure uniformity.

Some data are published best by presenting a tabulated statement of facts, others by graphic charts.

The range of territory covering the performances should not be too great, for people are more interested in the work of their neighbors than of those a thousand miles away, and the comparison of the work will probably be on a more equitable basis. However, the comparative territory is a matter of selection. In some instances, the subjects may cover a wide range of territory.

The following subjects on maintenance of way work were submitted in the report:

APPLYING TIES

This to consist of:

Unloading and distribution of new ties.
Removal of old ties.
Insertion of new ties.
Collection and disposal of old ties.

Comparison to be made upon number of ties applied in track per man per hour.

APPLYING BALLAST

The following details to cover the work:

Stripping track.
Unloading ballast.
Raising track and tamping ballast.
Lining and surfacing track.
Trimming ballast to standard cross-section.
Cleaning up surplus ballast.

Comparisons to be made on a basis of hours of labor per linear foot, properly equated if there is a material variation in the average raise.

LAYING RAIL.

The following details to cover the work:

Unloading and distributing rail and other track material.
Adzing ties.
Laying new rail, including full spiking and bolting.
Tightening bolts twice.
Picking up and loading rail and other track material released.

Comparison to be on a basis of hours of labor per mile of track laid.

CONSTRUCTION OF PILE TRESTLE BRIDGES.

The following details will cover the work.

Unloading all new material.
Driving piles.
Framing and applying all new material including ties.
Removal and disposition of all old material.

Comparison will be made on a basis of hours of labor per linear foot of bridge. Bridges of approximately the same height should be compared. In time an equation factor can be developed for varying heights. Time consumed in traveling is to be eliminated in the comparisons.

PAINTING.

Buildings—Details covering same to be:

Transporting tools and material to and from paint car.
Erecting ladders, scaffolding, etc.
Scraping all loose paint.
Applying putty to weather cracks and [illegible] defects of like nature.
Mixing and applying new paint.

Comparisons to be based on hours of labor per square of 100 feet.

PAINTING.

Steel Bridges—Details covering same to be:

Transporting tools and material from paint car.
Erecting ladders, scaffolding, etc.
Cleaning and scraping metal.
Mixing and applying new paint.
Cleaning up after work is done.

Basis of comparison to be hours of labor on bridges of equal length.

Modern Counterbalancing in Locomotives

In a paper read by Mr. Frank Williams before the Monston Branch of the Engineering Institute of Canada, the various destructive forces exerted by a locomotive on the rail were classified and the several features of design such as equalizers, pony truck suspension, and counterbalancing, were discussed in some detail. As impact on the rail is of vital interest to track engineers, we quote the following from his discussion of the counterbalancing feature:

In 1915 counterbalancing methods underwent a radical change as the result of a report submitted by a committee appointed by the American Railway Master Mechanics' Association to investigate the matter. The chief point established by this committee was that reciprocating parts were usually heavier than necessary, and that the total weight of these parts should not exceed a certain definite ratio to the total weight of the locomotive.

As a result of the conclusions arrived at by the committee the rule generally adopted by locomotive designers today is to keep the total weights of the reciprocating parts on each side of the locomotive below 1/160 part of the total weight of the locomotive in working order, and then balance one-half the weight of these parts, distributing this overbalance evenly between all the driving wheels.

The dynamic augment caused by the centrifugal force of the overbalance is then checked in order to make sure that it will not exceed one-half the static load on the rail when the locomotive is running at a speed in miles per hour equal to the diameter of the driving wheel in inches. If the centrifugal force of the overbalance were to exceed the static load on the rail at any particular speed the wheel would actually lift clear of the rail every time the counterbalance weight went over the top center, or if the centrifugal force were only slightly less than the static load and the locomotive happened to be rolling a little, it might lighten the static load at the instant when the counterbalance weight was passing the top center and the same condition would obtain; but when the locomotive is balanced in accordance with the present day method it will be agreed that there is no chance of the wheel lifting under any service conditions.

It is generally conceded by engineers who have made the closest study of these matters that dynamic augment is not in itself specially destructive to the track, but if it should be great enough to lift the wheel it will be accompanied by impact and in this case it might be very serious.

Bill for Relief of Yards and Docks Contractors.—The Committee on Naval Affairs of the House of Representatives on May 31 reported favorably the Britten bill (H. R. 6,678), which, in substance, is the measure prepared by the Relief Association of Yards and Docks Contractors. The bill as originally drawn only covered public works contracts under the Bureau of Yards and Docks, but this has been expanded to include all navy contracts. The bill in its revised form provides that compensation to be paid shall not increase the contractor's net profits on any of the jobs in controversy to more than 6 per cent. One important change extends its application to contracts entered into but not completed before April 6, 1917, instead of covering only contracts entered into after that date.

New Illinois Utility Bill Condemned By Western Society of Engineers

The Board of Direction of the Western Society of Engineers has transmitted to the Governor and the members of the General Assembly of the State of Illinois a detailed protest against the enactment of House Bill No. 741, which would put the regulation of the State's public utilities in the hands of a much enlarged commission with a greatly reduced volume of work to be handled, and the practical elimination of civil service.

Before the protest to the Governor and Legislators, the matter was given very thorough consideration. Acting under instruction, a sub-committee on public utilities studied the bill and prepared a report which it submitted to the Public Affairs Committee of the society. The Public Affairs Committee approved the report and transmitted it to the Board of Direction with the following comment:

"The committee believes that engineers, generally, must take the stand that the regulation of public utilities should be state-wide or district-wide. The extent of the regulating district depends upon engineering, legal, and fiscal, and not upon political considerations.

"We believe that the proposed House Bill No. 741 would be a very harmful piece of legislation. It will result in endless confusion including conflicting jurisdictions and, in some cases, no regulation at all. It abolishes all safeguards over civil service and gives the commissioners much less to do, and at the same time more than doubling the total salaries of the commission.

"The Public Affairs Committee recommends that the report attached hereto be approved by the Board of Direction, sent to the Governor and to the membership of the state legislature, and given all possible publicity."

This in turn was approved by the Board of Direction, and transmitted. The text follows in full. The side headings were introduced by the editor.

Changes Proposed in the New Law.—The above mentioned bill now before the Illinois Legislature for passage and an enactment into law, makes radical changes in the present law. It will, if passed, have such consequence on the future of this state, its welfare and its utility service, upon which its welfare largely depends, that every citizen should know what changes are proposed, and what the changes will accomplish. Briefly, the changes proposed by the new law are:

A. Name, "Illinois Commerce Commission": This name is substituted for "Illinois Public Utilities Commission," and forces a change of name on all records, forms, schedules, reports, etc., now on file or in stock.

Conflict of Initials.—The initials "I. C. C.," which will commonly be used on all schedules, legal reports, records, etc., in place of the full name, are already established and published as belonging exclusively to the Interstate Commerce Commission.

The provisions of the act do not reveal that the purpose of this commission is to regulate commerce, as generally understood, but is restricted to the regulation of public utilities. The name is, therefore, illogical.

The change of name will permit evasion of civil service by abolishment of offices.

Fifteen Commissioners to Replace Five and to Have Less Work.—B. Composition: The commission is to consist of seven commissioners with annual salaries of $7,000 each, and eight assistant commissioners at $5,000 yearly each (total $89,000) to be appointed by the governor for a period of four years, without restriction as to political party.

The present commission consists of five commissioners with annual salaries of $7,000 (total $35,000). Thirty-seven states have commissions consisting of three commissioners; six have five commissioners and only one other has seven commissioners. Inasmuch as further provision is included in this bill, so that by means of so-called "Home Rule," the jurisdiction of this commission over cities adopting the Home Rule will be removed, the enlargement of the commission is not justified.

The 1913 Illinois law provided a term of six years, and that not more than three of the five commissioners should be members of the same political party, and also provided for the progressive appointment of the commissioners, so that there would be a continuous, non-partisan, non-political commission.

In 29 states the term is 6 years; in 2 states the term is 7 years; 1 state has 10 years, and only 8 states have 4-year terms.

The 1917 amendment to the Public Utilities Bill was in itself a backward step, as it permitted the complete appointment of the commission by the incoming governor, and removed the restriction as to political parties.

Civil Service Evasion.—C. Appointments: The bill provides that employes shall not be included in the classified civil service of the state.

The present law puts all accountants, engineers, experts, clerks and employes (except only heads of departments and others who may be exempted by the Civil Service Commission) under the classified civil service of the state, and subject to the civil service act in force July 1, 1905.

Exemption from civil service would permit the Governor to make a complete change in the personnel employed under the commission at any time and for any reason.

Furthermore, the bill permits the commission to designate any person to make investigations and to conduct the same as prosecutor without restriction as to salary. This would permit a special prosecutor in each county or city to act as an additional "assistant commissioner."

Exemption of Municipalities and Districts.—D. Transportation District: The bill provides that any utility operated by any "transportation district" or other municipality is taken from under the regulation of the commission, and, further, "the powers conferred by this act upon cities shall not apply to nor control transactions by or with any transportation district organized under the laws of the state.

This means that if this is put into effect in Chicago, the transportation district will not be subject to state, public regulaion in any way, and would be also free from city council control.

Poorer Service at Lower Cost.—E. Standards of Service: The bill provides that rates shall be based upon standards of service, but also provides that, if these standards are not met "the rate shall be adjusted to the service actually rendered."

When the state establishes a standard of service, if reasonable (and in order to be legal it must be reasonable) this standard should be maintained, and the utility should not be permitted to maintain a degraded service at a lower price.

This change is a radical departure from the theory of all utility regulation laws existing. It is untried and fraught with possibilities of favoritism of the worst kind.

Monopony and Competition.—F. Convenience and Necessity: A certificate of Convenience and Necessity is required before a new utility can begin operations, but the bill provides that it shall be the duty of the commission to grant a certificate of Convenience and Necessity to a competing company if the service of the operating company is found to be inadequate. The commission is also authorized to revoke certificates previously granted. The bill provides that, "No certificate of public Convenience and Necessity shall be construed as meaning a monopoly or exclusive privilege, immunity or franchise."

Under these provisions, where the commission for any reason, satisfactory or ulterior, desires to recognize a monopoly in utility service, it may do so; if, on the other hand, they do permit competition, the condition reverts to the old chaotic state which was so distastrous to utility service in former years, prior to commission regulations.

G. Home Rule.—Article VI provides, "Any city exercising powers under this act shall have authority to exercise such powers by municipal ordinance, or otherwise, as such cities shall determine.

This permits a return to obsolete, discarded and unsatisfactory direct rule by the city council. It does not provide for expert or special regulatory authority other than the city council, and no provision is made for uniformity of standard rate of service or rate of compensation. If any city should appoint an expert supervisiong body, there would be a duplication of service provided for by the State Public Utility Commission. In all probability, there would be inefficiency and incompetency permitted in such local appointments.

The elements of good and adequate service and the establishment of just and reasonable rates are matters of engineering study and calculation, and they can never be determined satisfactorily by argument or by popular vote.

A study of the accumulated records of the commissions of various states shows that the fundamentals and the general solutions of the problems of one city are the same as those of another city. Public utilities are essential to the growth of American cities. A utility, to prosper sufficiently, must be permitted to create credit which will enable it to add yearly sums necessary for the expansion of plant and other investment of public service.

H. Passes.—The act provides that "any common carrier engaged in the transportation of persons between points within the state, on demand, shall furnish transportation free of charge to the Governor, Lieutenant Governor, Secretary of State, Auditor of Public Accounts, State Treasurer, Superintendent of Public Construction, Attorney General and members of the General Assembly while traveling to and returning from the seat of Government, and while necessarily traveling on official business."

A more revolting return to the old abuses which were abolished many years ago is hardly possible.

The Committee's Objection.—"The engineer is endowed by his profession and the state with specialized knowledge for peculiar and special service, involving the life, safety, comfort and convenience of his own and coming generations." Having special knowledge of and experience in the regulation and conduct of public utilities, and in full realization of civic responsibilty, we condemn the proposed enactment of house bill No. 741. It is misleading in its provisions. It is a return to the various unsatisfactory former utility regulation, or lack of regulation, and practice. It places in the hands of the administration a large appointive power without civil service restrictions.

The change in name would permit the wholesale discharge of the present technical staff of the commission, under the guise of abolishing the office and the substitution therefor of untrained, inexperienced employes for political purposes. It would disrupt any standard of service or rate, and would render of little value the investments of thousands of citizens in the present utility corporations. In place of safeguarding these investments and increasing the state-wide regulation, it would permit it to disintegrate into uneven and chaotic conditions. The pretense of abolishing the Utility Commission is not borne out by the proposed law.

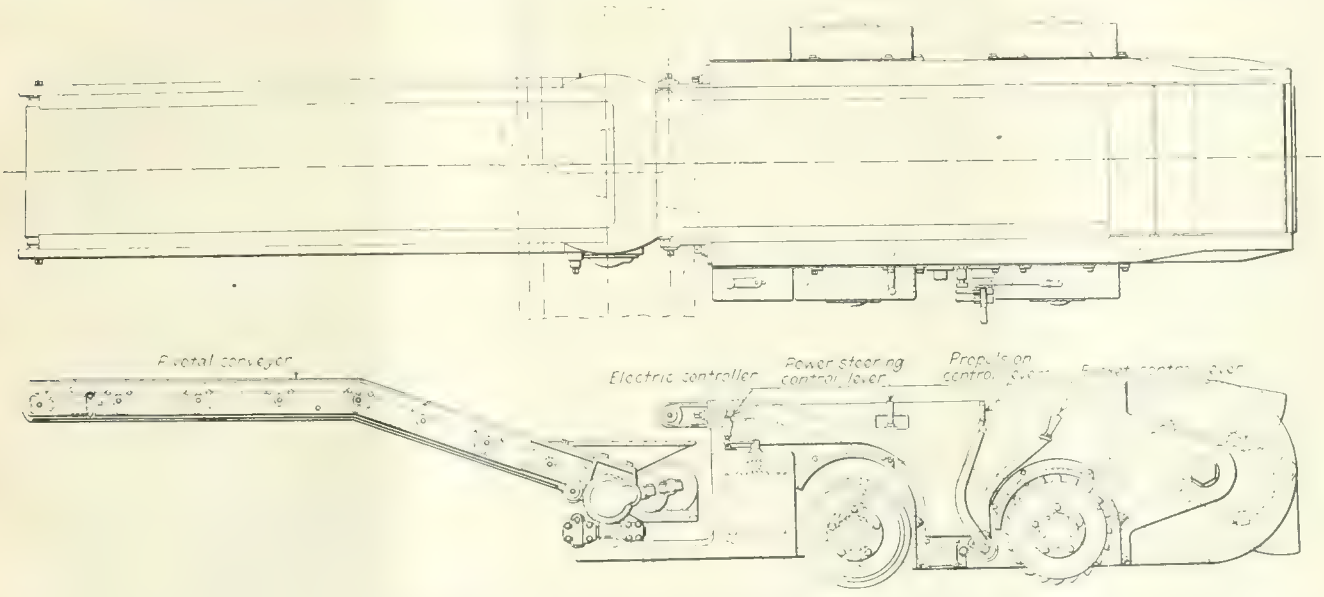
If abuses outlined above are permissible, it is folly to close our eyes to the obvious.

Moral vs. Material Progress.—"Belief in the possibilities of scientific progress is only the second most important thing in the world. The most important thing is the belief in moral and spiritual progress. Because one people forgot this we had four years of horror."—From an address, "The Organization of Research in a Democracy" on June 8 by Dr. R. A. Millikan, professor of physics, University of Chicago, vice chairman, National Research Council, at the annual banquet of the Western Society of Engineers.

A New Rotary Mechanical Shovel for Mucking and Loading Work

A new mechanical mucking and loading shovel, which utilizes a rotary motion in delivering its material to the car, has been developed during the past year by the Milwaukee Coke & Gas Co. of Milwaukee, Wis. The machine was designed by Mr. S. H. Hunt, chief engineer of the company, and is described in a recent issue of the Coal Age from which the accompanying illustration and notes are taken.

Digging is accomplished by four revolving buckets which thrust themselves forward into the pile of material to be loaded in such a manner as to be readily filled, dump their load upon a belt and then recede into the cylinder to which they are attached. The action of these buckets is positive; they are actuated by a cam of high wear-resisting quality. The process of loading is practically continuous instead of intermittent.



Plan and Elevation of Shovel and Conveyor, Showing Various Points of Control.

A conspicuous detail in the design of this machine is the complete housing and protection of its mechanism against dirt and water as well as the extremely rough usage to which such equipment is subjected in a mine. The working range is 10 ft. in width, all movements being controlled by three hand levers and one foot lever. The end of the belt which delivers material to the car has a fixed central point of discharge regardless of the angle with the track at which the scoop shovel may be working. Because of the low center of gravity of the machine, its stability in any working position is such that rail clamps and outriggers are unnecessary. This loader is driven by a single 15 hp. motor.

This machine was given its first test in loading coal cars at the face at the Weeksbury mine of the Steel & Tube Co. of America. The roof of the working place in which it operated was 39 to 42 in. about the track. Under these conditions the average loading time per car of 1¼ tons capacity was 45 seconds. During the three consecutive days that time and tonnage were observed in loading by mechanical means the rotary shovel averaged 260 long tons per shift of eight hours, showing a reduction in comparison with hand labor costs of 74.2 per cent.

The new machine has a three-point suspension, causing the two driving wheels to be in contact with the floor at all times, no matter how irregular the floor may be. Steering is accomplished by power. The wheelbase is sufficiently short to permit the machine when moving from one part of the mine to another to follow the track curvature without steering. The pivotal belt can be raised or lowered and swung through an arc of 180 degrees. The length of the machine proper is 8 ft. 10 in., the over-all width is 4 ft. 2½ in., and the height, measured from the rail, is 36 in.

Breakage and Heat Treatment of Rock-Drill Steel*

By BENJAMIN TILLSON.

[illegible] of rock drill [illegible] in place of the old reciprocating piston drill probably is one important cause for the greater steel breakage. Perhaps the manufacturers of drill steel have failed to realize what alloys are needed for this new service or have overlooked the changes in the art of rock drilling. The mine operator may be at fault in desiring to use the smallest possible drill-steel section in order that the gage of the drill bits may be correspondingly small and the amount of footage drilled per unit of labor may be greater; or the blacksmithshop practice at the mines may need improvement. The miner who uses the drill steel may also require more intensive supervision and education. Again, the manufacturer of rock drills may have failed to study the types of blows the steel alloys will withstand satisfactorily and which their tools are delivering and so he may not know whether or not a different design of rock drill would equal or excel their present drilling speeds without treating the drill steel so severely. All of these hypotheses probably have their supporters.

On the other hand, perhaps we are seeking too much service from drill steel and we need a fuller realization of the fatigue strains developed and should prepare to relieve these by a periodic heat treatment of the steels. However, we do not find any proof that any of these suppositions may be held responsible for the drill-steel-breakage attendant to mining.

U. S. Bureau of Mines Investigation of Drill Steel.—The proposed investigation of this matter by the U. S. Bureau of Mines is fully warranted in the promotion of the conservation of labor and material, and the safety of the workmen. The great range of field conditions, as well as the scope of the research, requires the energetic co-operative support of many interests.

In order to direct our attention to what are thought to be some of the salient features of this research, the following preliminary outline has been prepared:

1. Study of steels that give the greatest service before failure by breakage of drill steel: (a) Nature of sections; (b) composition; (c) methods of manufacture.
2. Maximum service that might be expected: (a) Life of steel; (b) methods of heat treatment; (c) standard methods for recording service.
3. Mechanics of failure: (a) micro-analysis; (b) nature of stresses; (c) detection of incipient failure; (1) magnetic analysis, (2) other methods not destructive of bar of steel, (d) is failure due to fatigue of metal?
4. Methods and machine development for accelerated tests: (a) Nature of forces involved: (1) impact; (2) vibratory compressional waves; (3) combined bending, vibratory, shearing, and torsional.
5. Correlation of field tests with accelerated laboratory tests.
6. Reclammation of depreciated drill steels: (a) Before failure; (b) after-failure; (c) methods of heating: (1) oil-fired furnaces, (2) electric furnaces: resistance (carbon or nichrome) induction (high-frequency or low-frequency), (3) ohmic resistance methods; (d) welding of fractured steel: (1) electric; (2) forge.

Mechanics of Failure.—It is not necessary to mention the various reasons why the microscope is invaluable in considering the metallurgy of steel nor the methods involved in determining the unusual conditions in composition, grain structure, and impurities that may occur in the drill steels. For the detection of the stresses that cause incipient failure, it is necessary to prepare a polished face along the length of the entire bar of drill steel, to protect this face from oxidation with a coating such as amylacetate, and to use every care when testing this steel to destruction. Such a procedure permits the detection of the local development of slip planes that occur at the surface of the steel, but it seems difficult to detect those originating within the bar.

The belief that the breakage of drill steel is largely due to the so-called "fatigue" of the metal has many proponents, but others contend that the problem of fatigue is of no importance and that the steel fails through lack of homogeneous suitable structure and that faulty manufacture or subsequent abuse are responsible.

Forces Acting Upon Drill Steel.—In order to get an idea of the magnitude of the forces acting on a drill steel, assume that a piston weighing 4 lb. makes 1,500 strokes per minute and travels 4 in. before it strikes the end of the drill steel; a drilling speed of 10 in. per minute advance of the drill steel in the rock, and a cross bit of 1¾ in. gage formed on the drill steel to cut the rock and rotated halfway around in an oscillating motion 50 times per minute, the cutting edges of the drill bit are formed by planes meeting at 90 degrees and presenting a surface 0.005 in. wide when sharp. Then the penetration of the drill steel in the rock will be about 0.1 in. per blow. The kinetic energy of the piston is about 69 ft.-lb. and the total average pressure on the rock will be about 8,300 lb. if the compressibility of the piston, the drill steel, and the rock are ignored as relatively small factors when compared with the depth of penetration in the rock. The crushing strength of granite is estimated from 12,000 to 20,000 lb. per square inch, we will use 14,300 lb. per square inch. If the initial pressure of contact of the steel against the rock equals this value, the final pressure would be 16,350 lb. of 22,800 lb. per square inch of drill bit in contact with the rock at the end of the penetration. This is about 60 per cent. more than the pressure required to crush the rock, so a corresponding portion of the force of the blows does no useful work but would be returned as a reaction through the drill steel if both bodies were perfectly elastic. The coefficient of restoration of steel, however, is ordinarily given as about 56 per cent., so that the rock could not return quite all of this excess force as a reaction on the steel.

If it is assumed that this steel has a modulus of elasticity equal to 29,000,000 lb. per square inch and a density of 489.6 lb. per cubic foot, the velocity of propagation of sound waves through it will be 16,550 ft. per second and as the time in which the piston is delivering its energy to the steel is 0.0005 second, the wave lengths will be about 8.275 ft.

Principles Governing Transmission of Compressional Waves.—Among the principles that govern the transmission of compressional waves are the following:

1. When a longitudinal or compressional wave passes from one medium to another, a part of the energy is reflected and a part transmitted. The phase of that part reflected is changed one-half of a wave length when the reflection occurs in the denser medium. When the reflection occurs in the lighter medium the phase of the wave is unaltered.
2. Two waves of the same length, but differing in phase, combine to produce a wave of the same length but different amplitude and phase than either of the initial waves.
3. Two waves of the same period and amplitude, but differing in phase by a wave length, combine to produce a wave of the same length but double amplitude.
4. Two waves of the same period and amplitude but differing in phase by a half wave length mutually annul each other.
5. Two waves that differ slightly in length combine to produce a wave of varying amplitude. Its frequency is one-half the sum of its component frequencies. If both initial waves were of the same amplitude, the amplitude of the resultant wave will vary from zero to twice the original amplitude as many times per second as the difference of their frequencies.
6. When two equal waves traverse in opposite directions, the resulting wave remains stationary. The node in the resultant wave occurs half way between the similar zero points of the original waves; and the points of greatest amplitude occur one-quarter of a wave length away. Therefore nodes occur at distances that are multiples of half wave lengths.

Special Engineering Board to Study Needs of Railways.—The National Association of Owners of Railroad Securities has appointed a board of economics and engineering to study the transportation system of the country and suggest economies and ways for bettering the earning power of the companies. The board will consist of six head engineers, with John F. Stevens as chairman.

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*[illegible] annual session of [illegible]

Classification System of Liberty of American Electric Railway Ass'n

The library of the American Electric Railway Association's Bureau of Information and Service has for its function the collecting and classifying, in a way to make instantly available, every scrap of information bearing on the electric railway business. How this mass of data, statistics and information is quickly sifted and classified is described in Aera by Julia R. Kelley, librarian of the association.

Although the system of classifying and manner of filing are very similar to that used in the general library, it has not the passive attitude of the latter but is active and aggressive.

System of Classifying.—All data is indexed or filed according to its subject, using a decimal system of classification. This system is a modification of W. H. Williams' "Railroad Correspondence File" and is developed in the same way as universally in the libraries throughout the country.

Using the railroad departments as a basis, the entire railroad field has been divided into seven major divisions, which can be subdivided into relative subjects giving the system a very wide scope.

To illustrate this, the following are the primary classes of the "Dewey Decimal System of Classification":

0—General works
1—Philosophy
2—Religion
3—Sociology
4—Philology
5—Natural science
6—Useful arts
7—Fine arts
8—Literature
9—History

The seven divisions of Mr. Williams' "Railroad Correspondence File" are:

0—General
1—Executive and legal department
2—Finance and accounts
3—Roadway and structures
4—Equipment and shops
5—Transportation and storage
6—Traffic
9—Local facilities and affairs

To show the working of the system, the divisions of class 6 (Traffic) are:

60—Traffic—general
61—Passenger traffic
62—Freight traffic
63—Baggage, handling and transportation of
64—Mail, transportation of
65—Express, transportation of

No. 62 is subdivided as follows:

620—Freight traffic—general
621—Products of agriculture
622—Animals and animal products
623—Products of mines
624—Products of the forest
625—Manufacturing

The naught is used in all cases to represent general subject; therefore 620 (Freight Traffic) is subdivided into:

620.1—Freight rates
620.2—Weighing and inspection
620.3—Routing and Billing
620.4—Soliciting freight traffic
620.5—Loading and handling
620.6—Milling in transit
620.7—Freight bills, collection and credit
620.8—Freight claims

A subject card index alphabetically arranged, on which is indicated the numerical classification, is kept readily available for any one not familiar with the files.

Material Collected.—Much time is given to discrimination in the selection and rejection of the great mass of material which collects daily in the library baskets. This is necessary in order to permit the library to contract itself into the smallest possible space, so that only matters of vital interest are kept. The material retained is represented by clippings from the technical press, statistical tabulations, indexes, periodicals, state commission reports, legislative acts, English tramway reports, annual reports of street railways, special reports of engineers on transportation problems, United States Census Reports, government publications, finance journals, municipal reference library notes, rate research bulletins, and proceedings of engineering societies.

How Material is Shaped for Use.—State commission reports, proceedings of the engineering societies and the English tramway reports are arranged alphabetically in sectional bookcases and are the only reports of which an accession record is kept. These reports are read carefully and the subjects in them are indexed on small cards. These cards are filed numerically and not only give the page of each reference on a subject but also a short summary. All cross-references are placed in this file, thus we have come to call it our "Table of Contents Card Index." All special reports are handled in the same manner.

Clippings from newspapers, periodicals, pamphlets, etc., are classified and filed numerically in large statistical filing cabinets. In these cabinets also are filed the special tabulations compiled by the association's statistical department.

Indexes Chief Reliance.—The "Industrial Arts Index" and the "Engineering Index" are frequently made use of. The indexes of Aera and the Electric Railway Journal are bound together in a loose-leaf binder. In a word, these various indexes are the main line of attack in making an investigation.

In order to handle a request from a member company, therefore, it is necessary to take the following steps:

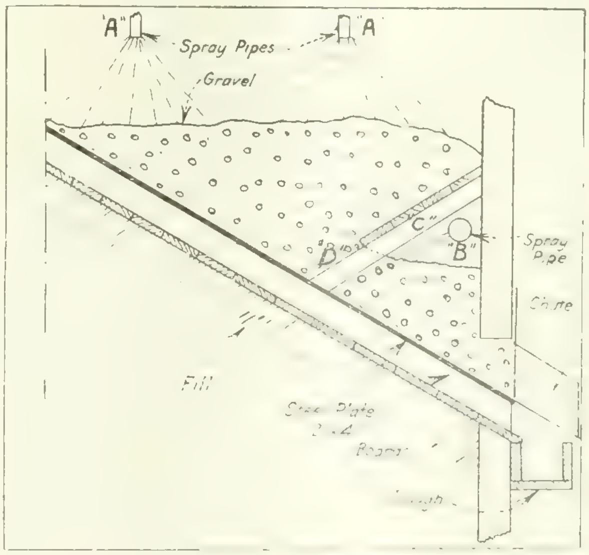
1. Find the subject's numerical classification in the subject card index.
2. The numerical classification leads to the statistical cabinets. Here are filed the standard tabulations, clippings, association's committee reports and all other loose matter.
3. The cross references from the "Table of Contents Card Index" are then looked up.
4. The special periodical and technical indexes are the next source of information.
5. All previous correspondence regarding a request for information on a subject is looked up. This correspondence is kept in a separate cabinet and filed by subject in the same manner as the statistical material.

This method of procedure is followed in all cases where necessary. Thus it is assured that all available data has been brought together for use in answer to an inquiry.

Device for Washing Gravel in Bins

An arrangement for washing gravel both in the bin and as it leaves the bin for loading into cars is employed at the Libertyville, Ill., plant of the Interstate Sand & Gravel Co. The device is described in Rock Products, to which we are indebted for the matter in this note:

The bin floor is made of 2x4-in. timbers with a perforated steel plate on top and boards on the bottom, the whole resting on an earth fill. The gravel is sprayed with water from the spray pipes "A" (see sketch). This water passes through the perforations in the steel plate to the board bottom which conveys it to the trough outside the bins. The spray pipe "B" washes the gravel as it leaves the bin for loading into cars. The housing "C" is made of wood with the ends boarded up so that there is only one opening "D" through which the gravel may pass. The housing is only as wide as the chute and there is one of these housings over each chute. The opening "D" is about 10x24-in. The arrangement was devised by Burton H. Atwood, President of the Interstate Sand & Gravel Co.



Half Section of Bin.

Functions of a Railway Employment Service*

The functions of an employment service may be stated as follows:

First, finding the labor supply; second, selecting from the available supply the right man for the right job; third, introducing each new employe to his foreman, his fellow employes, and to his work; and fourth, following up each new employe to see that he is engaged in the work for which he is best suited, with a view to making desirable changes and transfers, and also as a check on the selection made by the employment office.

Advertising at once suggests itself as a means of getting in touch with labor and it will produce good results if properly directed. As a rule, employers do not resort to advertising until the labor shortage becomes acute. Advertising, however, should be carried on with a view of getting in touch with the most desirable class of labor and inducing this class to enter railroad service. To accomplish this, the advertisement should state in effect that the railroad employs a large amount of labor and give a list of all the most important classified jobs. It should state the opportunities for advancement and should appeal to those interested to write direct to the superintendent of employment or apply to the nearest agent for an application blank.

Every agent or office of the railroad should be supplied with these application blanks. The blank should contain a fairly complete list of the most important jobs and the applicant should be required to check off at least three of the jobs which he would prefer. There should also be space on this blank for the applicant to state his age, nationality, previous experience and give references. This application blank should be mailed direct to the superintendent of employment, either by the applicant himself or by the agent.

When an application of this kind is received, it should be acknowledged at once and if no position is open in the class as checked off by the applicant, he should be so advised. If there are other jobs open that would seem to be suited to him, the applicant should be advised of that fact. If no job at all is open, the applicant should be requested to communicate further at a stated time, one month, two months or three months, in the future. If the applicant does communicate further at the time stated, it is an indication that he is desirous of getting into the railroad service and if there is still no position open, he should be placed on the preferred list and also be put on the mailing list for any railroad magazines or any other literature sent out by the railroad that would maintain his interest in railroad work. By consistently following up a system of this kind, a very much better class of labor can be secured.

There is another part of this work that should not be overlooked. Representatives of the employment service should visit high schools, academies, and colleges along the line and give talks to interest students in railroad work. These talks should be given with the idea of explaining various features of railroad organization and operation and in such a way as to interest not only the students, but the general public. Such talks will create a better understanding between the public and the railroads and also draw a considerable amount of very desirable material into railroad service.

Selecting the Best Men.—The next feature of the employment service is the selection of the best men from the available supply and placing each applicant where he is most likely to succeed or "make good." The process of selection in the first place is one of elimination. The first step is to have each applicant interviewed by a representative of the employment service at the point most convenient for the applicant. After the interview, the employment representative should investigate the references given by the applicant. This will eliminate the obviously undesirable without the necessity of the applicant appearing in person at the nearest employment office. It goes without saying that the employment representative should be a man of wide railroad experience and he should not summarily reject any applicant without some very good reasons and these reasons should be stated in his report to his chief.

The next step is the physical examination. In the interest of public safety all applicants having contagious or venereal diseases must be eliminated at once. However, such physical examinations are well understood and no comment is necessary here.

If the applicant is recommended by the traveling representative of the employment service, and is physically fit, he should be sent to the nearest employment office, where he should be given an interview by men trained for that purpose. Instead of being given an application blank and told to go and fill it out and bring it back again, he is taken into a private room and seated comfortably with the interviewer. The interviewer asks the questions and fills out the application blank. During the conversation, which is carried on in a very friendly manner, the interviewer draws out as much of the family history and experience of the applicant as possible. He also takes pains to explain the policies of the company with regard to promotions, pensions, insurance, or anything else that directly affects the welfare or contentment of the employe. He also explains the necessity for safety, and service to the public.

At the end of the interview, the interviewer should make a brief but lucid statement of his estimate of the applicant's qualifications and abilities. It may be difficult to secure competent interviewers in the beginning, but, by systematic effort, a sufficient number of interviewers can be developed and of course the employment office should always contain men who are in the process of training for this very important work.

Psychologists, phrenologists, and other types of character analysts have devised a large number of tests for which they make various claims. There is no doubt that some of these may be a distinct aid in selecting employes, but they will have to be developed very slowly and it will be impossible to make practical application of these tests at the present time. I would favor, however, the placing of expert psychologists on the staff of the employment superintendent for the purpose of assisting in the training of interviewers, who must be practical men, and in suggesting methods of selection. After all, the chief object to be attained is to place the applicant where he will do the best work and where he will be happy in his employment. The best guide in doing this is the applicant's preferences. It is impossible to build up a perfect organization if any considerable number of the individual employes are discontented. A great many applicants may not know what kind of work they want; others may think they know, but because of lack of experience find that they did not know their own preferences. For this reason, it is necessary to follow the man up after he has entered the service, and see that he is placed where he can do the best work and where he is contented.

Following Up New Employes.—First impressions are too important to be left to hit-or-miss methods. When the new employe is ready to go to work, he should be introduced to his immediate superior officer by a representative of the employment service. He also should be introduced to some of his fellow workmen if possible. He should be told what equipment he will need and where he can get it, the practice with regard to pay days, and any other items of information that will help in the first few days of his employment.

The following up of employes by the employment service after they have actually entered the service is very important, and should be handled systematically. There should be enough representatives of the employment service so that every new employe can be interviewed by one of them within a week. A second interview should take place within three weeks of the date of entering the service. These interviews should develop any misunderstanding the employe may have and will impress upon him the fact that the company is vitally interested in his success and welfare. These interviews should also develop whether or not the employe is satisfied with his work and whether the foreman or supervising officer is satisfied with the new employe. If dissatisfaction does exist, the employment service should take the necessary steps to investigate further and make transfers, or take any other steps to promote harmony and satisfaction.

When it comes to promotions, vacancies can often best be filled by men already employed in some other department. Heads of departments at present are not in a position to know the abilities and qualifications of men in other departments, but a centralized employment service could and should keep a list of likely men in all departments, with a view to filling any vacancy that may occur.

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*[illegible]

The Ideal Drill Steel*

By FRANK H. KINGDON.

The essential qualities of a drill steel are: First, it must be easily forged; second, the forged bit end must be such that it can be easily heat treated to obtain hardness to resist chipping; third, the bar or body must be stiff to resist bending or twisting and yet tough to resist shock and vibration, with resulting breakage, and fourth, the forged shank end must be such that it can be easily heat treated to obtain some hardness with great toughness.

Requirements Ideal of Drill Steel.—Drill steel must be properly forged either by hand or machine, and this operation requires pyrometric control. I believe two causes of grief can be eliminated at this point, as there is no doubt that drill steels as a rule are forged at too high temperatures, and the forging operation is continued after the temperature has dropped below the critical. Furthermore, little if any annealing is done on drill steel after forging; hence the forging operation must be conducted with great care.

Assuming the forging temperature is correct, the other minor requirements are that the bit and the shank be in alignment with the body; that the shank shall be of the proper shape and length and the shank collar or lugs be of the proper diameter and length; that the hole, if any, be free from obstruction; that the striking end of the shank be flat and square; that the bit be of the proper shape, with the cutting and reaming edges formed full and to the required size; that the reaming edges are concentric with the axis of the steel, and that there are no sharp corners at the shoulder where the bit blends into the body.

It is obvious that the above requirements can best be obtained day in and day out by means of a drill steel sharpening machine. The efficiency of such a machine will accordingly depend, first, on the initial forging temperature required, for the lower the initial forging temperature the better the steel structure; second, on the accuracy of the forged bit and shank; third, on the speed of operation; fourth, on restriction of the hole in the shank and bit when using hollow drill steel; fifth, on the number of heats or times required to heat the steel before securing the finished bit or shank, and sixth, on the air consumption or power required. The means of heating for forging will be considered later.

The drill steel must have an ideal bit and shank. The essential qualities of such a bit, regardless of the conditions under which it is operated, are that its shape be such that maximum cutting speed can be maintained for as great a distance as possible before wear of the gage and cutting edge reduces the speed of penetration to a point where a change of steel is made necessary, and that the size or diameter of the drill hole corresponding to the gage of the bit can be maintained with the least possible reduction as the depth of the hole increases, and also that the shape of the bit is such that it can be correctly and readily formed and heat treated.

Features of Bit Design that Require Attention.—It is doubtful whether a standard bit can or will be developed that will suit all conditions, such as the force and frequency of the blow transmitted to the bit, the speed and strength of the rotation imparted to the drill steel, the character of the rock as regards hardness, abrasion and other factors, and the method for ejection of sludge or rock cuttings. Accordingly, the following features of bit design require attention: Shape, total length, and angle of cutting edge; length and area of the reaming edges or surfaces; size and shape of clearance grooves for ejection of cuttings, and length and angle of the wings and the manner in which they are blended into the body of the steel.

Cutting Edge and Its Application.—The combined length of the cutting edge and the manner in which it is applied is a big factor in the drilling operation regarding the speed and the life of the drill steel and the drill. The longer the cutting edge the greater the amount of rock cuttings per blow, assuming that the cutting edge is and remains sharp or sharp enough for the conditions. Furthermore, the drilled or blunt edge, besides decreasing the penetration per blow, lessens the cushioning effect, and this causes the drill steel to rebound from the rock, which may cause breakage of the drill steel or parts of the drill. In a radial cutting edge bit the work done is greatest at the extreme cutting and reaming edges, which accounts for the unequal wear along the cutting edge. Therefore it is apparent that the only way to improve this condition is so to shape the cutting edge that the work is evenly distributed throughout its length, and so that the extremities of the cutting edge have suitable reaming surfaces properly tapered back to improve the wearing qualities of the gage.

A good deal has been written about the angle and shape of the cutting edge, and many kinds of bits have been brought out, such as the bull bit, rose bit, double cross bit, chisel and double chisel bit, and other types, but so far as I know the only bit that approaches the ideal bit is the double-arc, double-taper bit. As to the ideal shank, there is no doubt that the so-called shankless steel approaches the ideal, and it is regrettable that this type is not suitable for all conditions. Its advantages and disadvantages are evident.

Proper Heat Treatment Most Essential Operation.—The third and last requirement of the drill steel which has ideal qualities is that it must be properly heat treated. This without doubt is the most essential operation in securing best results, and yet it is safe to say it receives the least attention. The good results which are expected from all previous operations can be obtained only through proper heat treatment. Theoretically, this operation of heat treating should be simple; practically it is not, for all too much depends on the equipment.

I desire to call attention to a few essentials. First of all, the pyrometric equipment, which is in a way the most important piece of apparatus for obtaining best results. It should be sturdy and accurate, and the cold junction should be automatically taken care of or compensated for. This function I believe is best accomplished by using lead wire of the same composition as the thermo-couple, thus bringing the cold junction to the indicator or galvanometer, where it can be compensated for by means of a coil. Of the different systems of reading the temperature I believe the potentiometer system is the most reliable for the drill steel hardening shop.

Of equal importance is the furnace, which should be so constructed that it can be used in heating for forging and tempering, that it can be adapted to heat any size or shape of drill steel, that the burner be placed so the flame does not hit directly on to the metal, that for continuous work the heating chamber have its maximum heat zone at the end from which the drill steel is withdrawn, and that the pyrometer or thermo-couple be installed in this end.

Some Points on Heat Treatment.—Without giving further description of the equipment, I will assume it is such that the following treatments can be accurately controlled and performed. In forging do not heat higher than 1,700° F. (with steels containing about 0.45 to 0.55 carbon, somewhat higher temperatures may be used), and use that lower initial temperature which will leave the temperature of the steel just above its critical as the forging operation is finished; anneal after forging to secure uniform results by heating just through the critical; heat from 50° to 75° F. above the critical, and quench for hardening (with high-carbon, hypereutectoid steels it may be advisable to use somewhat higher temperatures to get the excess cementite into solution); draw the temper when necessary, depending on rock conditions.

In heating maintain a neutral or reducing atmosphere to prevent scaling and decarbonizing. Do not heat too rapidly or too slowly, but evenly and uniformly, as too rapid heating may develop checks or cracks, and too slow heating may cause soaking, which tends to large grain growth. For hardening, heat just above the critical temperature, as a properly forged steel quenched from this heat has in combination qualities of some toughness, with maximum hardness and maximum density. The quenching bath should be kept at a uniform and approximately constant temperature. In drawing or tempering, longer time periods at lower temperatures are better than the shorter time periods at higher temperatures.

To improve further the ideal drill steel it seems necessary to consider the steel itself. Is everything being done by the steel manufacturer that possibly can be done? I think not. But it would be useless for the manufacturer to bring out better steel and alloy steels when mine conditions are such that the present steel is not heat treated properly to obtain its maximum efficiency.

Best Type of Bit and Causes of Resharpening.—It is interesting to note that answers to a recent questionnaire brought out the following facts and are representative of all fields and conditions of mining.

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*From a paper presented Feb. 16 at the 123d meeting of the American Institute of Mining Engineers.

To the question, what type of [illegible] the best service, returns showed that the double arc, double-taper bit and cross bit were far in the lead.

To the question as to what necessitates the resharpening of the drill steels most frequently, wear of gage was unanimously first choice; chipping of bit was unanimously, with one exception, second choice; breakage of shank was unanimously, with one exception, third choice; upsetting of bit, upsetting of shank and breakage of body were about on a par for fourth choice.

To the question as to what was the direct cause of the necessity of resharpening, poor heat treatment was unanimously first choice, and faulty steel and severe rock conditions were about on a par for second choice.

The information set forth brings out two distinct facts which can be considered with equal advantage by the steel manufacturer as well as by those interested in this subject. There is no doubt that "wear of gage" depends on heat treatment, but, assuming proper heat treatment, could not a steel be developed which would improve this fault? For instance, chromium imparts to steel a quality of tough hardness with great resistance to wear and abrasion. Would such a steel improve our ideal drill steel?

With this in mind future experiments can be conducted so as to bring out the difference between high and low-carbon steels, straight-carbon and alloy steels, high and low-forging temperature, annealing and not annealing after forging, and as regards the body of the drill steel, the difference between steel as rolled and steel heat treated to obtain a refined sorbitic structure. Particular attention should be given to the temperatures, for little if any data in this particular have been given on such experiments as have been conducted.

Erie Shovel's Caterpillar Type Mounting Is Completely Lubricated

After three years of experiment and test the Ball Engine Co., Erie, Pa., has brought out a fully lubricated caterpillar type mounting for its Erie shovels and cranes. Tests of this new mounting are stated to have shown that after 40 or 50 miles of travel, there is no appreciable wear, and practically no maintenance cost whatever. On this new Erie mounting, every bearing is fully protected against undue wear by a film of special heavy oil, a lubricant which works equally well in hot weather or below zero. The link bearings are not allowed to run dry and "cut," but are protected like other important bearings on the Erie shovel. Not only greater endurance, but far more traveling speed and climbing power are claimed to result from the reduction of friction in the new Erie mounting. A caterpillar-type Erie is stated to travel at a speed of more than a mile an hour on high gear and to climb grades up to 25 per cent on its own power. The lubrication of the Erie caterpillar-type mounting is easily taken care of. One filling of the oil reservoir provides for at least a month's steady service. Once a month the operator spends about an hour in going all over the mounting with a squirt gun. Another very important feature of the Erie's continuous-tread mounting is the perfect steering, controlled entirely by the operator from his regular position in the cab. The operator can turn sharply either to right or left, or when desired can turn right about in one spot. The Erie caterpillar-type mounting is easily interchangeable with ordinary traction wheels or standard gauge car wheels, on the same truck frame. The result is that any Erie on traction wheels can easily be changed over to caterpillar-type, and then later changed to car wheels if desired, without any alteration to the truck frame.

[illegible] Erie Shovel on New Caterpillar Type Mounting.

New Compressed Air Hoist

A portable hoist having a new design of rotary type compressed air engine has been brought out by The Denver Rock Drill Manufacturing Co., Denver, Colo. In this hoist the whole engine revolves within the motor-housing, an oil and air-tight casting which protects the engine from the atmosphere and also serves as an oil reservoir. The distributor, through which the air is supplied to the cylinders, is a hardened and ground stationary steel shaft which serves not only as a distributor of power, but as a support for the cylinder block as well. Fixed to the spider shaft is the spider, a drum-shaped casting, which revolves within the motor-housing and within which the cylinder block also revolves. Around the inner side of the spider four hardened and ground steel tracks are mounted, on which the piston rollers run. The spider hub is mounted on a ball bearing. The spider-shaft is a carefully heat-treated alloy steel shaft upon which the cable drum revolves. A clutch pinion is mounted on the small end of the spider shaft so that the cable drum gearing can be disconnected from the engine and the drum permitted to run free when desired. The hoisting capacity is 500 to 2,000 lb., at 100 lb. air pressure, hoisted vertically at the rate of 68 to 143 ft. per minute, depending upon the weight of the load; loads of 500 lb. or less at pressures as low as 20 lb. The drum capacity is 755 cu. in. of rope space which will accommodate the following lengths of various rope sizes: 1,000 ft. of ¼-in. rope; 465 ft. of ⅜-in. rope; 225 ft. of ½-in. rope. The dimensions of the hoist are: Length over all, 24½ in.; height, 19½ in.; width, 17½ in. The weight complete without rope is 335 lbs.

Waughoist in Mining Operations.

Labor Wage Decision a Signal for Opening up of Business.—In a letter sent out to all officers and employees of the Illinois Central R. R., C. H. Markham, President of the road, states the decision of the labor board in regard to the reduction of wages, will result in a substantial decrease in the operating expenses of the Illinois Central system, and that it is intended to invest that money in maintenance which has been deferred—in the employment of additional men, and in the purchase of materials and supplies. He states that this railway has not waited for the money to come in, but has already entered upon a program and that he believes other railways will do likewise. The action of the labor board, therefore, he says, operates as first signal for the opening up of business, which will be bound to benefit the public at large. The crop prospects are favorable. This railway recognizes its pressing duty to place its roadway and equipment in condition to serve them this fall. The labor board decision will help to enable it to meet that duty.

New Sullivan Portable Column Hoist

A hoist having several novel features has been placed on the market by the Sullivan Machinery Co., Chicago, Ill. The engine in this hoist is a modification of the compressed air motor used in the company's Turbinair coal cutters. The hoist, in brief, consists of a cylindrical drum, mounted on a steel frame, and completely enclosing the operating mechanism. This comprises a Sullivan Turbinair motor, and a reduction gearing which drives the drum shell. The hoist is provided with fraction clutch and brake. When both of these are released the rope may be pulled freely from the drum. The friction clutch may be locked in position and the load raised or lowered, controlled entirely by the throttle valve. The brake is of the band type and is of sufficient strength to hold any load within the capacity of the hoist. The air is admitted at the axis of the drum through a hollow shaft, and the motor revolves with the drum. Ball bearings are employed, and all mechanism is totally enclosed and well lubricated. The rotors are lubricated by an automatic oiler. The hoist may be mounted on a cross bar or column in a shaft, winze or raise, for handling drills, steel or timbers; it may be bolted to a timber or girder or to a wall or floor, for pulling cars, piling lumber, and any odd jobs of hoisting or hauling. Its capacity is 1,500 lb. dead load lifted vertically at 100 ft. per minute, under 80 lb. air pressure. The hoist weighs 285 lb. and its drum will accommodate a maximum of 500 ft. of 5/16 in. wire rope. The overall length is 22 in.; width 13½ in., and height 15¾ in. The net weight (less rope) is 285 lb.

Sullivan Turbinair Hoist "Slushing" in Mine.

Re-Painting Old Street Cars

Mr. Leon W. Wolf, The Johnston Paint Company, Cincinnati, Ohio, writing in "Aera," has the following to say in regard to repainting old equipment:

"More than 200 street railways in the United States, Canada, the Philippine Islands, England and France are following my formula today for the repainting of street cars. By this formula we remove the necessity of burning off or removing the old paint, no matter how badly cracked or checked a street car may be. This means a saving of from $30 to $50 per car before ever you start to paint. Under this method of car painting old cars are repainted in from 3½ to 4½ days, and cars are running in many cities in the United States that have gone for over a period of 5 years, none of these old paint cracks have shown, and all that is done to these cars is to bring them in and revarnish them every 12 to 15 months. This is accomplished in the following manner:

Bring the car into the shop and sand off (do not wash off or scrub); remove all grease spots with gasoline or benzine; glaze up all side swipes, holes or indentations with glazing krakno; then apply one coat of krakno; allow the car to stand four hours and apply second coat of krakno; allow car to stand over night.

Second day, sand off car with No. 1 sand paper and smooth off with No. 00 sand paper; then apply a coat of smooth coat; allow this to stand two and a half hours and apply one coat of enamel; allow this to stand over night.

Third day, letter, stripe and varnish. This gives you your car for service the following morning (3½ days).

Railroad Technical Engineers Before U. S. Labor Board

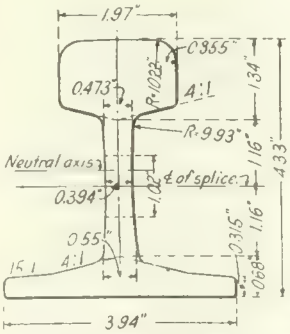
The Southern Pacific R. R. cited the Southern Pacific Section of the American Association of Engineers to appear before the United States Labor Board on June 6, for the adjustment of railroad compensation and working conditions. This appearance, brought about by the Southern Pacific R. R., was in connection with an effort by the railroad to reduce salaries of engineers employed on its lines and at the same time a request by the Southern Pacific Section of the Association for an increase in pay. The American Association of Engineers was represented by C. E. Drayer, national secretary, and R. C. Bailey in charge of chapter activities, including railroad work. In summing up before the Board, the Association presented the following facts:

> For many years a discouraging differential in compensation paid has operated on the railroads against the technically trained professional men. This differential was accentuated by the application on the part of the roads of Decision No. 2 (last year's wage increase) of the U. S. Labor Board, which did not specifically mention the professional engineer. They did not appear before the board and were apparently not in its mind when the decision was drafted.
>
> We will show in the exhibits submitted that not only should no decrease be put into effect, but that an increase should be granted to bring the salaries of these men to the minimum schedule proposed for those positions by the American Association of Engineers, Southern Pacific Section, thus removing the discrimination which now exists.
>
> The technically trained men perform services comparable to that rendered by medicine and law—professional services. The engineer is a staff man and performs service essentially executive in character.
>
> We are brought into this hearing by the management. We had hoped because of the staff character of the service of the technical men that it would not be necessary to appear here for adjudication of the dispute and that the question could be settled amicably by management and representatives of technical men.

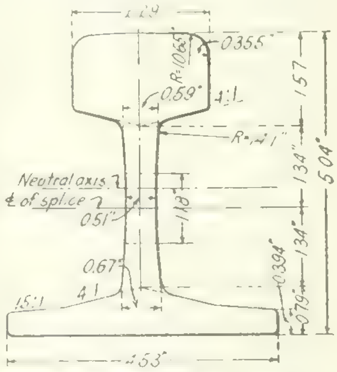
It is expected a decision will be reached by the Labor Board sometime before July 1.

French Rail Sections

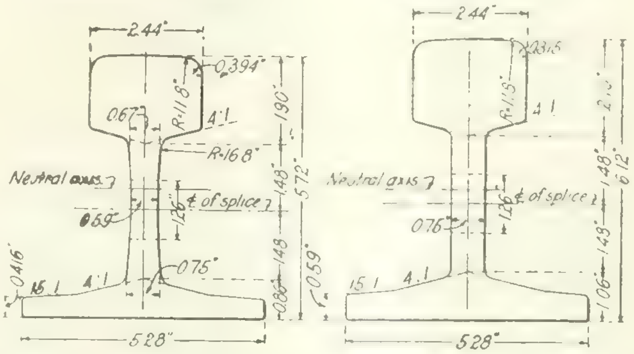
Four new standard rail sections have been adopted by six of the principal railroads in France after an extended investigation which included a study of American sections. The accompanying illustrations are reproduced from the Railway Age.



26 Kg (52.3 lb.) Rail.



36 Kg (72.6 lb.) Rail.



46-kg. (92.8 lb.) Rail, 55-kg.-(110.9 lb.) Rail for Tunnels

An Investigation of Excessive Fees Paid to Appraisal Experts in Chicago, and a Recommendation for New Plans of Employment and Payment

Following an editorial on the subject of excessive fees, printed in the May 4 issue of Engineering and Contracting, the editor-in-chief, Mr. Halbert P. Gillette, was requested to appear before the Finance Committee of the Chicago City Council to explain his criticisms in detail and to present suggestions for the betterment of an admittedly bad situation. In his discussion before the committee Mr. Gillette stated that of the many appraisals conducted by him and aggregating about three quarters of a billion dollars, none had cost more than one-half of 1 per cent of the appraised value of the property, and most had cost considerably less.

Four Per Cent Appraisal Fees.—The city of Chicago is paying each of its two building appraisers at the rate of 1¼ per cent of the appraised value of the property, where a bare appraisal is involved, and an additional ¾ of 1 per cent is added where drawings are furnished. So far as is now known drawings have been submitted by both appraisers in every case, thus making the appraisal cost 2 per cent for each expert, or a total of 4 per cent to the city. About $70,000,000 worth of buildings is being appraised at this rate in connection with various projects of street opening and widening in accordance with the city plan.

Fees on Other Work.—Mr. Gillette stated that percentage payments for appraisal work were very unusual, that he believed such a basis to be unsuitable, and that he himself had never appraised property at other than a per diem rate. He also stated that in his experience the cost of building appraisals had not exceeded the rate of ½ per cent on mixed properties as a whole, and he quoted from Prof. Horatio A. Foster's book on valuations that, "A safe estimate for the cost of valuing large properties is from three-tenths to five-tenths per cent of the total value found."

Confusion Over Architects' Fees.—The statement had been freely and emphatically made by city officials who were primarily responsible for the 2 per cent rates and the employment of experts under them, that the established rates of the Illinois Society of Architects and the American Association of Architects for such work were 8½ per cent, and that the city was accordingly getting its work done for one-quarter of what it would have cost private individuals. To show that this statement was completely in error, Mr. Gillette presented the latest, and very recent, schedule of charges of the Illinois society, and read the following there from:

"The architect's professional services consist of the necessary conferences, the preparation of preliminary studies, working drawings, specifications, large scale and full-size detail drawings, and of the general direction and supervision of the work, for which, except as hereinafter mentioned, the minimum charge is 6 per cent, based upon the total cost of the work complete."

From a succeeding section of the schedule he showed that the analyses of the 6 per cent fee is as follows:

	Per cent.
[illegible]	1.2
[illegible]	1.8
[illegible]	0.6
[illegible] Size Detail	0.6
[illegible] of the Work	1.8
[illegible]	6.0

none of which relates to valuation. As a matter of fact, the schedule contains no provision whatever for the valuation of property, and neither does the schedule of the Chicago Chapter of the American Institute of Architects. At the close of the meeting Mr. Gillette offered to investigate the subject further without expense to the city, and to report at the next meeting of the Finance Committee. This offer was accepted.

The Investigation.—The investigation was in part blocked by the refusal of the appraisal experts to allow access to any of their work except the very limited number of blue prints which had already been partially examined. This prevented any analysis of the appraiser's methods or costs of estimating, but left a limited opportunity for the investigation of drawings for which the city had paid ¾ per cent to each appraiser.

There were available three volumes of blue prints containing a total of 340 sheets mostly about 2½ ft. by 4 ft. in size. By far the greater part of the prints were for residence buildings—several residences usually being shown on a single standard size sheet. The prints had been made from pencil drawings on tracing paper—nearly all to a scale of ⅛ in. to the foot. They consisted of simple floor plans showing over all dimensions but very few details or interior dimensions, and sometimes a section of one wall. A true quantity survey could not be made from them. The amount which the city had paid for these drawings was not obtainable because the bills for services had for the most part been rendered in lump sums for large groups of structures, without any itemized statement of the amount of each.

Actual Test Made.—Fortunately for the investigators some of the earlier of the appraisers' bills were itemized, and one of these—an old brick residence appraised at $9,440 present value—was selected for a test. One of Mr. Gillette's assistants unaided made very thorough measurements of this building in 3 hours' time, and a draughtsman made floor plan drawings to the scale of ⅛ in. in 2½ hours. From this work, the actual cost of the plan of this building was estimated as follows:

Field measurements, 3 hrs. at $1.50	$4.50
Draughting, 2½ hrs. at $1	2.50
Blue prints, 4 sets, 10 sq. ft. at $0.01	.40
Overhead charges, 10%	0.70
Total	$8.10

For their plans of this building, each of the two appraisers for the city received ¾ of 1 per cent of $9,440, or $70.80—a total of $141.60 for plans which cost Mr. Gillette only $8.10. The comparison is made in this manner, for whatever the necessity of two or more than two appraisers of value there is no reasonable necessity of independent plans by each. But the cost of the plans to Mr. Gillette was at a rate which would have been excessive for that with which he was comparing; for the field man, while a competent engineer, was not a praticed building surveyor; the field measurements were in very much greater detail than appeared on the city appraiser's plans; the draughtsman was not accustomed to working from the field man's notes; and the finished drawings were in more detail and of generally better character than were the appraiser's.

As the cost of expert appraisal services was covered by the 1¼ per cent portion of the fee, while the ¾ per cent was distinctly specified as being for plans, the excessive character of the charge for plans appeared obvious—at least as respecting that class of buildings which constituted the great majority of all involved.

Reconstruction Plans.—The plans of large buildings varied in character, but none were in great detail; and the "reconstruction plans," of which much had been said as explaining the high cost of the work, appeared only as sketches showing possible arrangements, and not in any way approaching working plans. Furthermore, of the 340 sheets examined, only 12 showed even this meager treatment of reconstruction.

Experts Copy Original Building Plans.—The character of many of the plans of large buildings indicated that they were copies of architects' construction plans. This appeared from the occasional introduction of ornamental details which would have been difficult to sketch in the field and were of little significance in the matter of appraised value; and from the frequent showing of concealed details such as footings buried in the ground, floor and girder construction and the position of reinforcement in concrete. The plans of a small bank were selected as the first case for investigation; and examination of the construction plans showed beyond question that the appraiser's drawings were mere tracings of portions of the originals. It was also learned from the bank president that a representative of one of the appraisers had called upon him some months previously and asked for a set of the plans. Not having them in his possession at that time, the banker had referred the man to the architects of the building. So far as the president knew, no measurements of the bank building had ever been made by any of the appraiser's employes.

The second set of architects' drawings to be investigated were the plans of a local telephone building. Prints of these were secured and taken to the next following meeting of the Finance Committee, and when laid beside the drawings of the appraisers there remained no doubt in the minds of any present that the one set was copied from the other. Mr. Gillette stated that these two cases were sufficient preliminary evidence of the character of much of the work for which the appraisers were each paid ¾ of 1 per cent; and that should a complete investigation of the subject be undertaken, it would be a routine matter to compare the plans for each of the many other cases where it appears that tracings were made from architects' originals. The case of the telephone building was striking in the amount of the payments and the cost of work done. A rough estimate of the value of this building was $167,000, ¾ per cent of which is $1,250. Taking twice this as the amount paid to the two experts gives $2,500 as the approximate cost to the city of Chicago of plans which might just as well have been blue printed from the originals at a cost of $12 at the ordinary commercial blue print rate of 4 ct. per square foot. Even allowing for tracing, which was really useless under the circumstances, the cost appears out of all reason, for a draughtsman experienced in estimating the cost of such work estimated that the entire set submitted by the appraisers could be traced in 140 hours. Allowing for tracing at the liberal rate of $1 per hour, the following estimated cost was worked out:

Tracing	$140
Overhead cost, 10%	14
Blue prints	12
Total	$166

Architects Testify.—The committee also listened to evidence from Richard E. Schmidt and W. W. Wheelock, both architects of standing in the community and with extensive experience in the appraisal of buildings. Both testified that the fee paid by the city was on its face grossly excessive.

The Charge of Politics.—Request was made of the President of the Board of Local Improvements that he secure the full set of appraisers' drawings and some of their bills of materials and detailed estimates so that the committee's investigation could be made complete; but the request was denied on the ground that the investigation was a political move intended to influence the election of County Judges to be held six days later. It was, however, promised that all of the appraisers' records should be submitted to the Finance Committee for full investigation after the election.

Considerable acrimony developed at certain stages of the meeting, and was particularly noticeable when reference was made to responsibility for the original establishment of the fees. It was stated that the Finance Committee had at all times consistently opposed them, and that the council itself, after having passed an ordinance authorizing the fees, changed its mind and repealed the ordinance, but that the Mayor vetoed the repeal.

Recommendation for Improved Proceure.—The committee asked Mr. Gillette to recommend a proper system of employment and pay for such experts, and in response to the request Mr. Gillette submitted a recommendation in writing at the next meeting as follows:

Mr. John A. Richert, Chairman Finance Committee, City Hall, Chicago.

Dear Sir:

Pursuant to your request I submit the following suggestions relative to future appraisals of real estate for the city:

Where the property values are large, two independent chief appraisers should be employed by the city to supervise the appraisals.

In gathering the data of quantities these two appraisers should not use separate corps of assistants, but should employ a jointly supervised organization. Disputes among experts seldom occur as to inventories of quantities, or as to the accuracy of drawings, maps and the like. Hence an economic waste usually occurs where independent inventories and drawings are made. The disagreements among appraisers are usually of the following nature:

First, as to unit prices to be applied to the quantities.

Second, as to the per cent of depreciation of the property.

Third, as to severance damage where only a part of a given property is condemned.

Neither of these three major matters of disagreement is of such a nature as to require that independent inventories and drawings be made by the two chief appraisers.

In selecting the two chief appraisers I believe the city should secure the advice of the local societies of engineers and architects, for it requires experts to select the best experts. The Western Society of Engineers and the Illinois Society of Architects should be asked to recommend six experienced appraisers, three being named by each society. From the list of three appraisal engineers one should be selected by the city, and from the list of three appraisal architects one also should be selected by the city, these two being appointed as chief appraisers.

These chief appraisers should be permitted to select their entire staff of assistants and clerks; for theirs is the responsibility for the appraisals. Included in their staff of assistants there will necessarily be men of very high professional and technical ability.

I believe that these two chief appraisers should direct the appraisal of the lands as well as of the buildings, and that they should be empowered to select expert real estate men familiar with land values in Chicago. This method of procedure is the one that I have long used in my own appraisal work, and it is in general use by other appraisal engineers.

The city should agree with the chief appraisers upon a time limit within which their appraisals shall be ready to submit to the court. Since most of the work of making an appraisal consists in making the inventory of quantities and since many subordinates can be employed on the gathering of such data, the time required to make an extensive appraisal is almost inversely proportional to the number of men employed in gathering the data.

The two chief appraisers should be paid on a per diem basis, and their subordinates on a weekly basis, the payments for their subordinates being made by the city itself instead of by them. Similarly all rentals, stationery, office materials, etc., should be paid by the city.

The chief appraisers should be instructed to make no unnecessary drawings. Where tracings of architect's plans of buildings are available, blue prints of those tracings should be secured even though this results in lack of uniformity of scale or size of blue print sheets. These blue prints can be checked against the buildings, so that the chief appraisers will be able to testify as to their accuracy.

Whether a detailed quantity survey should be made of any building or whether cubic foot contents will suffice is a matter of judgment. Hence this decision should be left to the chief appraisers. It should be remembered, however, that the cost of making an appraisal by the cubic foot method is usually but one-third to one-fourth as great as when made by the detailed quantity survey method.

A chief appraiser can not possiby be acquainted with every detail of a large appraisal. Where this acquaintance with a given detail is challenged in court, one or more of his assistants must take the witness stand. Also it occasionally happens in a hard fought case that a chief appraiser will need the support of witnesses other than his own assistants. The city, therefore, should be prepared to employ such expert witnesses as the chief appraisers may desire. These special expert witnesses need be employed only for a few days. In this way a great weight of testimony can be secured at much less expense than where complete appraisals are made by several independent appraisers.

Yours truly,

(Signed) HALBERT P. GILLETTE.

Road Form Department of Heltzel Steel Form & Iron Co., Not Damaged By Recent Fire

The plant of the Heltzel Steel Form & Iron Co., Warren, O., was partly destroyed by fire on June 2. The company, in addition to being manufacturers of steel forms for concrete road, sidewalk, curb and gutter and other concrete construction, are fabricators of general plate construction. The steel fabricating department suffered most from the damage. The steel form department has continued operation almost uninterruptedly since the fire, shipments of steel forms being made a short time after the fire. Because of the present road building campaign throughout the country, the steel form department of this company was very busy at the time of the fire, and they are indeed fortunate that this department was not damaged to a great extent. Immediate steps have been taken to get the steel plate fabricating department back into operation, and it is expected within a few days, wheels will be turning in this department.

New Track Laying Machine

A new track laying and lifting machine brought out recently by the Clyde Iron Works, Duluth, Minn., consists of a structural steel frame for placing on a standard flat or logging car, and carrying upon an upper deck a two-drum engine to operate a load line and a "traffic" line. An open space is provided in this structure under the upper deck or platform for carrying the rails and passing bundles of ties through to and from the tie car in the rear. Two cars hooked up with a locomotive, the machine car ahead and tie car next to the locomotive, comprise the equipment in readiness for operation. Steam for operating is taken from the locomotive through pipe and standard steam connections furnished with the machine. A reducing valve is furnished with the machine for mounting on the steam connection to the locomotive for carrying a uniform pressure of 80 to 100 lb., although the engine on the machine is amply strong and heavy to carry the usual boiler pressure.

Clyde Track Machine Placing Rail.

The frame structure is solidly built throughout and properly braced to produce a maximum of rigidity. The members are all thoroughly riveted except the four legs which form the top or peak structure. These are bolted to the top of the main frame to detach readily if necessary. The three lower cross beams provide skids or supports for the rails and the machine is clamped to the car platform at each corner. The trolley track is constructed of two channels [illegible] and hot riveted to [illegible] strong and durable girder with the flanges forming a track for the trolley carriage to traverse, and permitting a construction of carriage with the wheels outside so as to be easy of access and lubrication. The trolley track is constructed in three sections and attached under the upper deck or platform, so as to provide clear passage for the carriage throughout its length. The trolley track or boom extending from the machine to the front is high enough over the road bed to afford ample facility for easily and readily swinging the suspended ties or rails to the proper location on the right of way when operating on the sharpest curves.

The main frame at the base is 26 ft. 8 in. long overall and 11 ft. 3 in. wide. Height of trolley track over road bed 15 ft. Height of machine from road bed to top of peak 27 ft. 6 in. These heights are based on standard flat cars about 4 ft. high to top of car platform. Length of trolley track 90 ft., projecting 45 ft. each way from center of machine. The machine is built for lifting a maximum load of 4,000 lb. at either extreme end of the boom and to carry the load either way the full length of the boom.

The normal hoisting speed of the load is approximately 100 ft. per minute, and the normal speed of the carriage traversing the boom is approximately 200 ft. per minute. The capacity of the equipment for the load of rails and ties depends upon the carrying capacity of the cars used and upon the railroad track. There is ample space in the machine for carrying 150 60-lb. rails, still leaving sufficient room to pass a bundle of 15 ties through the machine.

The number of men required to operate this machine would vary somewhat under differing conditions. A normal crew, however, under ordinary and average circumstances would consist of 13 men arranged or classified when laying track as follows: one foreman, one engine operator, one rail man on the car, one tie man on the car, four spikers, two nippers, two bolters, one spike peddler. This crew and the arrangement contemplate spiking every alternate tie ahead of the machine. The two men on the cars designated as rail man and tie man work together on both cars as the work requires. The distribution of this crew when taking up track would be about as follows: One foreman, one engine operator, two rail men on the car, two tie men on the car, two bolters detaching angle bars or splice plates, four spike pullers, one spike peddler. With a crew as outlined above it is stated that the machine will lay from 225 to 300 or more lineal feet of track per hour. Taking up track usually proceeds somewhat faster than laying.

Unique Exporting of Construction Equipment

On March 19th the Austin Machinery Corporation of Chicago received an urgent Mexican shipment order from the New England Fuel Company. This called for an Austin Model 6-T crane rigged for clamshell bucket operation.

This machine was loaded at Toledo immediately and on arrival at ship's side at Port Arthur, was met by a big tanker awaiting the crane's arrival with steam up. A little gasoline and oil were put into the engine,—it was cranked up once,—the engine turned over, and the machine walked off the freight car under its own power, across the dock, across two 12x12 timbers laid between the dock and the boat, crawling directly onto the deck of the tanker, which was all ready to put to sea. The tanker's derrick picked up the boom of the crane from the flat car, set it on the deck, and the machine and boom were lashed down on the deck the same afternoon and the tanker immediately got under way. The run to Tampico was made in a few days, the lashings were cast off, and again the machine walked off the deck of the tanker under its own power onto the private dock of the oil company. The tanker's derrick again picked up the boom, loaded it on the dock, the boom was fitted to the crane and it immediately walked to its working location and started doing its job just 26 days from the day order was placed.

Classification of Costs in Sand and Gravel Operations

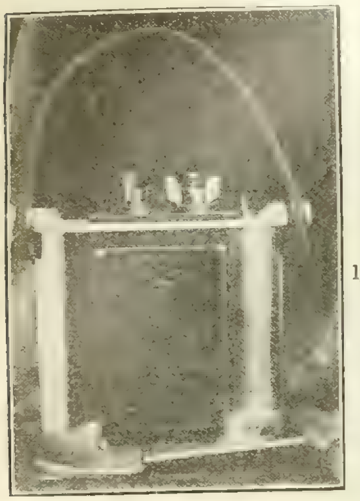
At the recent convention of the National Association of Sand and Gravel Producers at Louisville, Ky., Mr. C. L. Ruffin, president and general manager of the Massaponax Sand & Gravel Co., Fredericksburg, Va., submitted an interesting analysis of the cost of a sand and gravel operation. The outline below, reprinted from Rock Products, gives the essentials of his cost-keeping system:

EXCAVATION—
  Wages, crew,
  Wages, groundmen,
  Fuel,
  Water,
  Lubricants,
  Repairs,
  Depreciation.
HAULING—
  Laying and surfacing,
  Train, crew,
  Train, fuel,
  Train, water,
  Lubricants,
  Locomotive repairs,
  Car repairs,
  Depreciation.
WASHING—
  Power,
  Wages.
TESTING.
  Repairs,
  Depreciation.
LOADING—
  Car preparation,
  Car loading.
ROYALTY AND DEPLETION.
SALES.
GENERAL (to be distributed to the proper account at end of period)—
SHOP MACHINERY AND TOOLS—
ADMINISTRATIVE—
MISCELLANEOUS—
  Rental,
  Insurance,
  Tax reserve,
  Automobile,
  Stores.

The overhead and administration expenses are carried out to the end of the operating season, and then to obtain the final unit costs of each step in the operation, these expenses are distributed under each of the main eight headings as the judgment of the man on the job dictates.

A Permissible Blasting Machine

The Davis No. 0 Blaster, manufactured exclusively for the Atlas Powder Co., Wilmington, Del., has just been put on the market. It bears the approval plate of the U. S. Bureau of Mines for use in gassy and dusty coal mines. Before the machine could be approved it had to pass strict tests which prove these qualifications:



Davis No. 0 Blaster.

(1) The Davis No. 0 Blaster develops enough current to fire one electric blasting cap used with rubber covered wire of lengths not exceeding 600 ft. for No. 14, 350 ft. for No. 16 or 200 ft. for No. 18 wire.

(2) No spark can be generated that will ignite coal dust or gas.

(3) The machine is solidly built and durable.

(4) The key by which the Davis No. 0 Blaster is operated is a separate part of the machine and may be kept in the possession of the shot-firer, preventing the operation of the machine by any other person.

The Davis No. 0 Blaster is small, compact, lightweight and substantially built to stand hard service. Its dimensions are 2x4x4½ in. It weighs but 3 1/16 lb. The outer case is a seamless brass tube, heavily nickeled, with aluminum top and bottom plates. A leather strap (removable) makes carrying easy.

News Letter

ST. LOUIS ITEMS.

By A. B. Koenig.

W. A. Gierke is finishing a small job of grading for the Burlington R. R. at Hamburg, Ia.

Mulvill Bros., Alton, Ill., have 40,000 yards of waste and borrow work to let in 8,000 to 20,000 yard quantities.

L. I. Viall of Kansas City was here the other day looking up a steam shovel job for his outfit, which is idle.

T. J. Morris has finished his road work at Carbondale, Ill. Is in the market for work suitable for a 20-team outfit.

R. T. Amis, 3932 Euclid Ave., Kansas City, Mo., has two good machines and one shovel outfit idle that he would like to place on work immediately.

Columbus S. Jones, the boss stationman, has 60,000 yards of team work near Benton, Ill., to sublet. 5156 Cates Ave., St. Louis, will catch him.

Contractors when in want of labor or work for their outfits write Koenig Labor Agency, 612 Walnut St., St. Louis, Mo., or 501 Delaware St., Kansas City, Mo.

The J. W. McMurray Contracting Co. has finished its masonry and concrete work for the M., K. & T. R. R. at Sedalia, Mo.; moved this outfit up the line onto a similar job.

Ed. Petersen of Petersen, Shirley & Gunther left the States with a number of foremen and experienced trackmen for their railroad work in Cuba. They have over 1,500 men at work there.

P. J. McGraw expects to be through with his work at Masonville, Ia., in a few days. Will have 9 teams idle that he would like to place on some grading in this part of the country. His address is 2232 McCausland, Ave., St. Louis,. Mo.

Tom Walsh and Dan Terry were here the other day looking over this part of the country. Walsh just had an operation performed on his nose to remove a growth that had formed in his nose. O. K. now. Nothing new, but will probably have something to report in next issue.

The contract for the construction of 26 miles of hard surfaced road in Howell County, from the Texas County line, near Willow Springs, to the Oregon County line, at Thayer, will be awarded soon by the Missouri Highway Board at Jefferson City. Bids were opened recently and the two lowest were those of M. E. Gillioz of Monett at $134,151 and Allhands & Davis of Springfield, $139,397. The third lowest bid was that of the General Construction Co. of St. Louis.

The C. R. Cummins Co., 1961 Railway Exchange Bldg., St. Louis, Mo., were awarded about 2½ miles of Illinois State Highway work near New Memphis, Ill. They have about 45,000 yards of splendid team work to sublet on this job. Paul Grafe, their local manager, will be pleased to show contractors over it. Are going to do the balance of this work themselves with a drag line.

Bids for the construction of the Rutger St. dock of the Government River Service, which is the barge line upon the Mississippi River between St. Louis and New Orleans, were opened June 4 in the office of Maj. DeWitt C. Jones, United States Engineer for this district. The lowest bid was that of the Frazier-Davis Construction Co. of St. Louis, $204,[illegible]. Other bids were: James Stewart & Co., St. Louis, $245,575; Ratermann Building & Construction Co., $267.101, and the Fruin-Colnon Construction Co., $332.490. The bids will be forwarded to Washington with recommendation by Major Jones and the award will be made by the War Department. The contract will call for completion in six months. The dock will be a combination local terminal and terminal for the exchange of freight between railroad and barge. The dock itself will be 480 feet long and will be backed by a local freight house 240x58 feet.

Personals

L. L. Harper has been appointed City Engineer of Quincy, Ill.

Albert Givan has been appointed City Engineer of Sacramento, Calif.

A. M. Wilson has been appointed City Manager of Colorado Springs, Colo.

W. D. Stayton, formerly Assistant Construction Manager of The J. B. McCrary Engineering Corp., severed his connection with that company on June 1 to become associated with the Wood-Rucker Construction Co. 502 Walton Bldg., Atlanta, Ga.

L. D. Davenport, formerly Chief Engineer for the Oliver Mining Co., at Hibbing, Minn., has sailed from Seattle for Manchuria to make a geological survey for the South Manchurian Ry. Co. W. H. Crago and Frank Hutchinson, Duluth engineers, are also members of the party. W. E. Emmons, Wisconsin State Geologist, and Warren Meade of Madison, Wis., are also included. Dean Appleby of the School of Mines of the University of Minnesota is heading the party.

Elvin J. Becker has joined with James M. Gagen in the establishing of the firm of Gagen Becker, Electrical Contractors and Engineers, 750 W. 181st St., New York, N. Y. Mr. Becker has been engaged for 15 years on large engineering and construction operations throughout the South and Middle West of the United States. Mr. Gagen has been identified with the electrical contracting business in New York City for the past 15 years, being the founder and president of Gagen and Butler, Inc., from which office he has recently resigned.

Obituaries

Major Frank R. Jones, a consulting engineer of Kansas City, Mo., was drowned recently in the Missouri River.

W. H. Moseley, 74 years old, died June 2 at Waco, Tex. He was well known throughout the South as a railroad contractor and lumberman, the greater portion of his life having been devoted to these two enterprises.

Michael J. Dady, contractor and political leader, died June 2 at Brooklyn, N. Y. In 1893 he organized the Micheal J. Dady Contracting Co. At the head of that concern Mr. Dady was identified with some of the most important municipal and Federal building and engineering construction in this country. In the early nineties he received from the Spanish Government a contract to install an elaborate drainage system for the city of Havana. The pipes and their tributaries were to have cost $14,000,000.

William B. Cogswell, founder of the Solvay Process Co., at Syracuse, died June 7 at his home in Syracuse, N. Y., aged 86. Mr. Cogswell was a graduate of Rennsselaer Polytechnic Institute, Troy. Prior to his organization of the Solvay companies, he was successively a railroad engineer engaged in the construction of the Syracuse & Oswego railroad and in relaying the tracks of the Syracuse & Utica R. R.; an apprentice mechanic in Lawrence, Mass., machine shops, superintendent of the Marietta, Cincinnati R. R., with headquarters at Chillicothe, O.; superintendent of the Broadway foundries, St. Louis, Mo.; mechanical engineer with the navy during the Civil War, outfitting a naval repair shop at Port Royal, S. C., which effectually aided the blockade of southern ports; builder of the Franklin Iron Works, Oneida County, and manager of lead mines at Mine La Motte, Mo.

Trade Publications

The following trade publications of interest to engineers and contractors have been issued recently:

Locomotive Cranes.—The Browning Co., Cleveland, O., 48-page catalog of the Browning locomotive crane. Contains detailed description and drawings of the crane, together with tables of capacities of standard locomotive cranes with different length booms at various radii. Construction views show many applications of the crane.

Cement Mill and Coal Tipple Equipment.—Webster Mfg. Co., 4500 Cortland St., Chicago, June issue of Webster Method, contains descriptions of Perkins pivoted bucket carrier in a modern cement plant; of the Conover-McHenry grain elevator, and a 5-track steel coal tipple.

Air Hoister, Motors and Winches.—Chicago Pneumatic Tool Co., 6 E. 44th St., New York City, 16-page bulletin devoted to hoisting and hauling by compressed air by means of Little Giant geared air hoists, motors and winches. Shows application views of this hoist in various industries and for many operations.

Drill Sharpener.—Sullivan Machinery Co., 130 S. Michigan Ave., Chicago, Ill. 32-page bulletin illustrating and describing the Sullivan drill sharpeners—a compressed-air machine for making rock drill and hammer drill bits by hammering.

Transits and Levels.—Warren-Knight Co., 136 N. 12th St., Philadelphia, Pa. 32-page pamphlet on "Sterling" transits and levels, engineering field equipment, etc. Contains description of new Model No. 1-c "Sterling" precision transit and new Model No. 16M "Sterling" engineers' wye level with reflecting mirror.

Locomotive Cranes.—Industrial Works, Bay City, Mich. 64-page catalog illustrating and describing the locomotive cranes made by this company. Contains numerous illustrations of various applications of the cranes tables of capacity and diagrams showing clearance and boom radius.

Ladder Type Excavators.—Pawling & Harnischfeger Co., Milwaukee, Wis. 16-page bulletin describing P. & H. ladder type excavators. Specifications and descriptions of all parts of these trench digging machines are included, as well as many illustrations of work done and excavators in action on various jobs. Brief refence is also made to the new P. H. "206" excavator-crane with full corduroy traction.

Industrial Notes

Actuated by a desire to assist flood-stricken Pueblo, the Pawling & Harnischfeger Co. has shipped, by special through train, a No. 206 Corduroy Traction Type Excavator-Crane, to the Mayor of Pueblo. This, they believe, will be of service in clearing up the debris, handling materials and for many other purposes.

The Hercules Powder Co., Wilmington, Del., has acquired the Aetna Explosives Co., Inc. By this purchase the Hercules Co. obtains high explosives of dynamite plants near Birmingham, Ala., Emporium, Pa., Sinnamahoning, Pa., Ishpeming, Mich., and Fayville, Ill.; two black blasting powder plants, one at Goes Station, Ohio, and the other near Birmingham, Ala.; a plant for the manufacture of blasting caps and electric blasting caps at Port Ewen, N. Y., and a plant for the manufacture of fulminate of mercury, for use in blasting caps, at Prescott, Ontario, Canada.

WEEKLY NEWS SECTION

HALBERT P. GILLETTE, Chief Editor of Engineering and Contracting
(Author of the Handbook of Cost Data for Contractors and Engineers)

For fourteen years this section of *Engineering and Contracting* has been noted for the reliability, freshness and usefulness of its construction and contract news.

ENGINEERING AND CONTRACTING

is the only national weekly periodical published west of New York City that completely covers the field of civil engineering and its allied contracting.

Its subscription price as a weekly is $4.00 a year—or less than 8 cents a week. Although its contract news completely covers the whole civil engineering field every week, its articles are so edited as to cover only one of the four major branches of the field each week. For an outline of this unique plan and its advantages, read the "mast head" on the first editorial page.

Bids Asked

Roads-Streets

Calif., Berkeley.—Until 4 p. m., June 21st, by the Board of Education, Berkeley School District, County of Alameda, for grading, curbing, guttering and macadamizing the western one-half of Grant street. Clyde Blanchard, Secretary, 2133 Allston Way, Berkeley, Calif.

Calif., Los Angeles.—Until 10 a. m., June 20th, by Board of Public Works, for improvement of Fawn avenue, Reservoir street and Elk avenue, consisting of constructing curbs, sidewalks, gutters graded and oiled roadways and pavements, for storm sewers and appurtenances, and for reinforced concrete culvert and catch basins.

Calif., Sacramento—Until 2 p. m., June 20th, by Calif. Highway Comm., 515 Forum Bldg., for construction of 5.7 miles in Butte County and 19.4 miles in Merced County. Autin B. Fletcher, Highway Engineer.

Ga., Homer—Until noon, June 28th, by the Board of Roads and Revenues of Banks County, at Court House, for furnishing labor, material and equipment necessary for the construction of approximately 7.25 miles of topsoil road from Maysville to Homer, Ga., known as the Georgia Federal Aid Project No. [illegible] and [illegible] miles of topsoil road from Baldwin to Hollingsworth, known as the Georgia Federal Aid Project No. 215. W. R. Neel, State Highway Engr.

Ill., Benton—Until 2 p. m., June 20th, by City of Benton, for construction of improvement known as "Paving District No. 11," total estimated cost $37,900. C. B. Mantz, Engineer.

Ill., Elgin—Until 3 p. m., June 22nd, by City of Elgin for construction of 5,880 lin. ft. cement concrete combined sidewalk, curb and gutter, 3,840 lin. ft. cement concrete [illegible] sidewalk and [illegible] 1,065 lin. ft. cement concrete combined curb and gutter.

M. H. Brightman, Commr. of Public Works. (Advertisement in this issue.)

Ill., Watseka—Until June 23rd by County Clerk, for the construction of four sections of concrete or bituminous macadam and one section of gravel road. Benj. Jor[illegible]

Ind., Danville—Until 10 A. M., July 5th, by Commrs. of Hendricks County, State of Indiana, for furnishing all material and for the construction of the improvement of [illegible] Highway [illegible] Twp., and the John Flinn et al. Highway [illegible]

Ind., Fort Wayne—Until 10 a. m., June 29th, by County Commissioners of Allen County, at Court House, for improvement of highway 13,822 feet in length, by grading, draining and paving with stone. Estimated cost $27,100. Road is located in Lafayette Township, and is known as Sheldon Road.

Ind., Hammond—Until 2 p. m., June 29th, by Board of Public Works, for the construction of cement sidewalk, on Torrance avenue.

Ind., Lafayette—Until 10 a. m., July 5th, by oJhn C. Doyle, Auditor of Tippecanoe County, for furnishing 10 barrels or more emulsified asphalt.

Ind., Richmond—Until 9:30 a. m., June 20th, by the Board of Public Works, for the improvement of North "A" Street and North 2nd Street, by constructing cement sidewalks, 6 feet wide, cement driveway, curb and gutter and paving roadway.

Ia., Sibley—Until 11 a. m., June 23rd, by Melvin F. Taylor, County Auditor, for approximately 22 miles of permanent grading on the Secondary Road System of Osceola County.

Kansas, Chanute—Until June 24th, by the City of Chanute, for the paving of streets. F. W. Austin, City Engineer.

Ky., Corbin—Until June 28th by Board of Common Council, for the construction of Gordon street with reinforced concrete.

La., Shreveport—Until 10 a. m., July 5th, by J. C. Flanagan, Secretary-Treasurer, Shreveport, for approximately 48,520 sq. yds. of paving and 6,000 sq. yds. of brick paving along the car track. H. E. Barnes, City Engineer.

Md., Baltimore—Bids being received by J. B. H. Jefferson, State Bank Bldg., Baltimore, Md., for quarrying and crushing stone by the ton.

Mich., Allegan—Until 1 p. m., June 16th, by Board of County Road Commrs. of Allegan County, Court House, for improving 4.198 miles in Casco Township, Allegan County.

Mich., Cedar—Until 1:30 p. m., June 17th, by Board of County Road Commrs., Leelanau County, Court House, for improving [illegible] miles of road in Bingham Township.

Mich., Detroit—The Detroit Asphalt Paving Co. was low bidder for paving as follows: Lyon Ave. at $21,162.

Mich., Ludington—Until 1:30, June 17th, by Board of County Road Commrs. of Mason County, Court House, for improving 3.157 miles of road in Ludington Township.

Mich., Sandusky—Until 2:30 p. m., June 21st, by Board of County Road Commrs., at Court House, for improving 5.027 miles of road in Austin Township, Sanilac County.

Mich., West Branch—Until 9 a. m., June 17th, by Board of County Road Commrs., for improving 2.998 miles of road in Ogemaw County, Ogemaw Township.

Minn., Duluth—Until 11 a. m., June 20th, by the Board of Public Works at office of F. D. Ash, City Clerk, for improving Marks or Twelfth alley, also for improvement of Michigan Avenue.

Minn., Duluth—Until 11 a. m., June 18th, by the Board of Public Works, F. D. Ash, Clerk, for improving Fifth alley.

Minn., St. James—Until 7:30 p. m., June 20th, by Christ Larson, City Clerk, for improving Armstrong Boulevard South, Local Improvement No. 5.

Minn., St. James—Until 7:30 p. m., June 20th, by City Council, for improving First Avenue South by laying of paving, gutters and curbs of concrete, known as Local Improvement No. 6.

Minn., St. James—Until 7:30 p. m., June 20th, by City Clerk, for improvement of First Avenue South, project known as Local Improvement No. 7.

Minn., St. Paul—Until 10:30 a. m., June 20th, by H. W. Austin, purchasing agent, City Hall, for grading and improvement of alley in Block 7, Sylvan Park Addition, for grading and improvement of East and West Alley in Block 1, G. G. Whitney's Addition, and Blocks 3 and 4, J. J. Kenna's Addition.

Minn., St. Paul—Until 10:30 a. m., June 20th, by H. W. Austin, purchasing agent, for grading and improvement of Lake Como and Phalen avenue by grading.

Mo., Kansas City—Until 2 p. m., June 21st, by the Board of Public Works, for constructing brick block pavement on Forest Avenue, constructing plain concrete on roadway of Troost Avenue.

Mo., Kansas City—Until 2 p. m., June 21st, by the Board of Public Works, for constructing concrete curbing and concrete sidewalk as follows: Curbing on Lexington, curbing on Park Avenue, on Wabash Avenue; sidewalks on Chestnut, Indiana, 70th Street, South Benton, 22nd Street and 31st Street.

Mo., Kansas City—Until 10 A. M., July 1st, at office of Leo E. Koehler, County Surveyor and Ex-officio County Highway Engineer, for the construction of revetment for the proposed reclamation of road on Wornall Road, south of Blue River, and for construction of road approximately 2,000 feet long and 30 feet wide, known as the Bannister Road, located in Section 34, Twp. 48, Range 32, Jackson County, Miss.

N. J., Newark—Until 10:15 a. m., June 20th, by the Department of Streets and Public Improvements, for paving on Os-

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The Cabinet's Opportunity, the Engineers Duty

William Howard Taft might, we believe, have performed a service which would have brought his name and the names of his cabinet into the foremost rank of constructive national administrators. One great achievement lay almost within grasp, and was lost. We refer to the establishment of government on an efficient basis. Reforms under Mr. Roosevelt had made government and business cleaner than for many years. The opportunity was ripe for a striking improvement in efficiency, and such a movement instead of interfering with further purification would have stimulated and accelerated it. For governmental inefficiency and corruption too often are bedfellows. Mr. Taft received the report of the Commission on Efficiency and Economy and sought its adoption. He failed; but with full recognition of the huge weight of opposition, we still contend that "it could have been done," and that the administration lost its greatest opportunity. President Wilson's failure to reorganize scarcely could have been avoided.

Today again—It can be done. Further still, we have better prospects for improved governmental efficiency than have ever existed before; but they are only prospects, and we cannot escape the lesson that they can be realized only after a bitter fight. The situation is this: a committee headed by Walter Brown of Ohio is at work with the definite support of President Harding and the cabinet to rearrange and reorganize the bureaus and the work of the various departments on an efficiency basis. If, as dispatches indicate, the cabinet is sincere and unanimous in its support of the work, it means that every ultimate head in the executive branch of the government is working for cooperation and efficiency. If success rewards their efforts they will have accomplished probably the greatest benefit that any administration could accomplish for the American people of today and tomorrow; for waste, if a lesser sin, is a greater expense than graft. It is needless to enumerate or to discuss particular wastes and inefficiencies. Any person interested in a recent statement can find one in an article by George Creel in Collier's Weekly for June 11.

Nor shall we attempt to detail the opposition which must be met. Bureau heads, subheads, and employees by the thousand are threatened with loss of position; and though not on the whole an energetic lot, they will not mildly submit to the ax. Already it has been necessary for President Harding to issue a warning through the cabinet that bureau heads and employees must cease interference with and propaganda against the reorganization committee and its work. These people are not bad: they are merely defending their personal interests as other people do. But the plain fact is that the rest of the country suffers for their benefit.

Representatives and Senators have heretofore assisted bureau employees in maintaining their jobs. This has been a more or less necessary political expedient, but with a President and cabinet energetically united against such policies the political value becomes less certain. It may even be that Congressmen will be called upon to explain such a course to their supporters at home. If a substantial public sentiment energetically favors efficiency, it cannot well be thrust aside; and engineers as apostles of efficiency should be in the fore front of the movement.

The reorganization committee will not be ready to make its recommendations before the regular session of Congress beginning in December. The support of Congress is indispensable, for the rearrangement of departments and bureaus; the assignment of functions to them, and the provision of funds are all in its keeping. A single cabinet officer would be helpless to effect any important improvement in the face of Congressional opposition. An entire cabinet can do more, only by reason of the political and moral force of its union.

For these reasons we urge our brother engineers to undertake active support of the efficiency movement, and to begin at once. Public sentiment already favors efficiency, but it is lethargic. It will arouse but slowly, and the entire time from now to December is not more than enough for it to make itself felt by its representative.

[illegible] stands still. If efficiency [illegible] it will take, [illegible] the depth to which it may [illegible] in a recent [illegible] ex-Governor Frank O. [illegible] of Illinois [illegible] follows:

> [illegible] rapidly [illegible] the number of public [illegible]
>
> [illegible] federal government [illegible] and [illegible] levy taxes independently. And when the limit of the bonding [illegible] reached [illegible] body with authority to levy taxes.
>
> This means that the number of persons who are obtaining their [illegible] public treasury [illegible] if the proportion of public employes continue to increase as rapidly as they have in late years we will, within a reasonable time witness this phenomenon: our population divided into two classes, those holding public office, still a minority, it is true, and all others working to support the minority in office.

The Development of National Park Resources

[illegible] promoter of the welfare [illegible] contractors [illegible] might be expected to favor [illegible] projects giving fair promise of economic success; but there is one class of such proposals which we cannot favor. We refer to the commercial use of the resources of our national parks. We believe that it would be an irreparable mistake to permit the erection of dams or other works within the areas now held exclusively for public enjoyment, and our reasons are these:

The love of nature is inherent in all men: with many it is a very deep love. Such men have a right to ask that there be preserved for them and their successors some portion of the nation's natural beauties unmarked by works of Man. Originally North America was as rich in natural beauty as in material resources. The development of the latter necessity has removed much of the former, and we think there can be no reasonable complaint with this fundamental fact. To have preserved a vast wilderness would have been to deprive mankind of benefits to which it was entitled, but to pursue the opposite policy of making every possible "development" and leaving nothing for beauty would also be to deprive mankind of rightful benefits. The difference between complete utilization of resources and moderate conservation of natural beauty is as great as the difference between miserliness and thrift; as between perpetual toil and a cheerful industry.

We do not believe that those seeking to utilize our park resources will dare to claim that beauties are unworthy of preservation because they are for pleasure. Rather, their moral contention seems to be that present park uses do not furnish the greatest possible good to the greatest number. But what is this good which is claimed? That some in America are inadequately clothed and fed is not due to insufficient production; and this leaves only some form of luxury as the "good" to which it is proposed to convert park resources. Will the proponents of "development" claim that more phonographs, fancy wearing apparel, children's toys, tobacco, colored pictures, or $1.35 novels are greater "goods" than the pleasures of escaping from all man-made surroundings, to traverse and to live for a little while in a beautiful and truly natural country?

Some, seeking the opening of the parks, may think like this, but we believe that their thoughts are fathered by commercial motives. A man can usually bring himself to believe anything which is for his apparent personal benefit. Frankly it is our opinion that the movement to open these tracts to industrial and agricultural development is promoted entirely by the selfish desires of individuals for personal gain. We call attention to this fact, not because selfish promotion is inherently reprehensible or against public interest, but because the unusual need for an appearance of public benefit in this case will arouse special efforts to present such an appearance and to obscure as far as possible the private motive.

As to the claim that the commercial welfare of the nation actually is to be furthered, the use of every stream and every stick of timber in every park would affect the nation's business by so tiny a fraction of 1 per cent that the nation's life would be no whit easier or richer.

It is claimed for some of the proposed works that instead of being disfigurements, they will add a picturesque beauty to the scene. These claims are sophistries: such beauty (and we willingly admit that there is such) is already to be found in 10,000 places; what is wanted in the parks is nature as much as possible unaltered.

It is further claimed that encroachments in the parks would be limited to a few of the most useful and least disfiguring developments. This, too, may be believed by some, but in the main it is simply misrepresentation, for an entering wedge will make other like entrances the easier. Precedents will be followed, as proved by the history of every grant of privilege or of opportunity.

Let us keep the parks for the purpose for which they were originally set aside. Let any who doubt that they are appreciated consult the records of the number of visitors each year, and note not merely the large numbers of a single year, but the rapid rate of increase in use. We most sincerely hope for the success of Secreary Fall and others in their opposition to the park development bills now in Congress.

The Demand for Industrial Freedom

"Co-operation of the farmers with the organized industrial workers of the country to 'achieve the ideals of economic, industrial and agricultural as well as political freedom' was pledged by the Farmers' National Council in a telegram received today at the convention."—Current news item from the convention of the American Federation of Labor now in session at Denver.

Recognizing that the desire for freedom is both natural and good, we nevertheless wonder if the farmers who sent this message, and others who most often raise such cries, really understand what they are talking about. They tell us that manual workers and certain classes of brain workers are enslaved; that the whip of starvation holds them to their jobs often in the face of inadequate pay and bad working conditions. That the whip strikes less frequently than such statements indicate, and that its menace is not greatly feared is, we believe, a fair conclusion from the data of innumerable strikes. Still this editorial is not a contention that industrial freedom exists: in fact it is quite the opposite.

In the present organization of society there is no complete industrial freedom, nor can there be complete freedom in any society except the primitive one where every family supplies all its own needs. The worker, it is true, may usually give up his job or change it without actual starvation; but not without injury to his welfare. For any degree of prosperity whatever he is dependent upon his employer as much as he is upon his own efforts. Escape of starvation is not freedom.

But the worker is not alone in his dependence. The employer is equally dependent on his employees, and there are records of strikes which have brought complete ruin on substantial enterprises. And outside the industry immediately concerned there is the vast dependent public that uses the product.

Few indeed of those crying for freedom would return to the primitive, but many talk of becoming their own employers in some advanced form of socialism or of communism. Such a thing is conceivable: the government might own and operate all property. But let us not be deceived as to freedom. In such a state men's acts would of necessity be most fully controlled: instead of more freedom there would be less. The worker could not quit nor change his job except with the approval of some board or commissioner. The strongest leader would secure the best pay or the best conditions for his own preferred classes of workers. The struggle for supremacy would continue. Human nature is improving, but not so fast that a change in form of government will make all strong men just.

We are not pessimists. The history of the world is a history of progress. Better things are attained daily, and they are attainable the faster for being intelligently sought. There are underpaid workers who should receive more, and also there are some who are over paid. There are bad conditions to be remedied, and good things now missed which can be had. These things, we believe, are better sought without appeals for a freedom which can not exist.

"A Day's Wage."—The good old slogan of fifteen years ago—"Eight hours' sleep, eight hours' play, eight hours' work, and eight dollars a day," now seems more popular with employers than with the employees. Perhaps Judge Landis of Chicago will decide which party is entitled to its use.

Book Reviews

Engineering Construction, Part I, In Steel and Timber.—By W. H. Warren, LL.D., Dean of the faculty of Engineering, University of Sydney, Australia 3rd Edition, 486 pages 12 plates, 453 Fig Longmans, Green & Co., New York, 1921 Price, $10.00

This new edition is called Part I: Part II will be devoted to Masonry and Concrete Structures. In this edition the text has been revised and two appendices added, one on Australian timbers and the other on recent tests on steel columns.

Reinforced Concrete Design, Vol. II, Practice. By Oscar Faber, D. Sc., A. M. Inst. C. E. 246 pages, 80 Fig. Longmans, Green & Co., New York. $6.50

This volume of Reinforced Concrete Design is called Practice, to distinguish it from Volume 1, called Theory. The difference as seen by the author is that Volume 1 gives a mathematical treatment of rigidly connected beams and columns requiring much time and ability on the part of the average designer to follow. The average designer can figure resisting moments very accurately; this accuracy, however, is only apparent as he is liable to err (even up to 100 per cent) in his determination of the bending moments. In the second volume the author is giving methods of obtaining bending moments quickly and accurately.

"To this end, actual bending moment diagrams for beams are given for any number of spans, any ratio of live load to dead, any conditions of loading, any fixity with monolithic columns of different relative stiffnesses, and in any practical case, the designer will find the appropriate curve, from which he has simply to read off the maximum positive and negative moment to provide against, at any distance along the span".

The problem of simplifying the design of continuous beams with unequal spans has interested many engineers. The author has an original solution of this problem, which is approximate but accurate enough for practical purposes. Diagrams give factors which are to be multiplied by the ordinary bending moment formulas; these factors depending upon the ratios of adjacent spans.

Bending moments in exterior and interior columns due to rigidity of connections and to uneven loading can be obtained from diagrams by means of factors to be multiplied by $\frac{wl^2}{12}$.

A chapter is devoted to standard beams and columns. Properties of these are tabulated for assumed sizes of members and amounts of reinforcing steel. These tables are intended to help in quickly finding the relative rigidity of beams and columns when obtaining bending moments on columns due to rigid connections. Another chapter gives the results of the author's researches in shearing action of concrete beams.

In the appendix are placed the London County Council Regulations for Reinforced Concrete. These regulations are more liberal than current American practice in some respects, but are quite conservative in others. For instance, the maximum unit shear on the jd section of a properly reinforced beam is 180 lb. as against our 120 to 133. (Note: Mr. Faber considers the maximum stress of 180 lb. as too conservative and "unnecessarily onerous.") On the other hand, the maximum compressive stress in bending is taken to be the same as the maximum direct compressive stress, whereas American practice allows an increase of about 50 per cent.

Secondary Stresses in Bridge Trusses.—By T. E. Mas, D. of Eng., Prof. of Bridge Engineering, Chinese Government Engineering College, Tangshan, China.

The paper is an abstract of a thesis presented to the Carnegie Institute of Technology for the degree of Doctor of Engineering. It gives an analysis for secondary stresses by an entirely graphic method based on deformation equations. The method possesses the advantage of several checks during the procedure.

A partly analytic method with simply arranged compensations is also given. Several sections are devoted to citing authorities on the influence of secondary stresses on the design of bridges.

The paper may be had upon application to the author.

Community Service by Professional Engineering Societies

Engineering is scarcely likely to command the place in the public esteem which its importance warrants until the public is brought to realize the far-reaching effect of the services rendered by technical men. Such conviction cannot be brought about by academic discussion in the professional engineering societies. However important these deliberations may be, they do not reach the layman and carry no weight with him. He must be addressed in the language he understands, and the tale that the engineer has to tell, or should tell should be often repeated. Other professions and vocations are, unfortunately for the engineer, much more articulate and receive a meed of public acclaim in direct proportion to the publicity with which their work is surrounded.

It is not to be expected that the deliberate introduction of topics of an engineering tenor into conversation on all possible and impossible occasions will yield the result sought. However much immediate success the classical personage who sells leather may have in persistently turning the conversation leatherwards, the engineer cannot much profit by his example. There are methods that are not only more subtle and more effective, but also more consonant with what we have been pleased to call professional dignity.

An instance of legitimate publicity work for the profession is brought to notice by D. B. Rushmore and R. F. Emerson in a recent number of the "Journal of the American Institute of Electrical Engineers." It is based on a real service to the community, and for that reason cannot fail to meet with success. The plan, which was worked out in Schenectady, consisted in giving a series of public lectures on science and engineering in simple, non-technical language under the auspices of the Schenectady Board of Education, the speakers being furnished from the local sections of the American Chemical Society, Illuminating Engineering Society, American Society of Mechanical Engineers and the American Institute of Electrical Engineers. Lectures on the following topics were given: Chemistry and Some Common Things; Light—Its Use and Abuse, in the Home, in the Street, and in the Place of Business; Forty Years of Railroading; The X-Ray; Submarine Detector Devices; The Wonders of Electricity. The first year's program has been brought to a very successful end, the attendance of the public showing that the opportunity to inform itself on the various subjects presented, was appreciated.

Some work of this kind is being done in the larger cities of Canada, but, for the most part by non-professional societies. In Toronto, the Royal Canadian Institute has done much to popularize science, of the "pure" rather than the "applied" type, and the same has been done in Hamilton, for very many years, by the Hamilton Scientific Association. Commendable though this work is, and however much it merits continuance, the professional engineering societies should not entrust the presentation of the brief for the scientist and the technician wholly to societies officially unfamiliar with the problems of engineering and the relation of the engineer to the public. The engineer should plead his own case and, preferably, it should be done through the existing professional organizations.—Editorial in The Canadian Engineer.

Labor Unions and Industrial Decay

If from the total of labor unionism in the United States there be subtracted the unions on the railroads, in the building trades and in the coal mines there is very little left. Of all the workers in the country only between 10 and 15 per cent belong to unions, and if the three monopolies are subtracted only a very small per cent is left.

These three classes of unionism must be taken as representing what unionism means. They represent conditions where unionism is successful. If now we should estimate all the work that should normally be done in the United States and allot it by percentages to crafts, the proportion allotted to coal mining, building and operation of the railroads would be far less than the percentage of wage drawers that are now in these lines of activity.

What does this mean but that these men are not doing their share of the work of society? They are drones, relatively speaking, supported in part by the rest of the workers. It is not so much that they receive too much money [illegible] it is that they [illegible] render a full day's work. In this respect they may not differ from their non-union [illegible], except that they have the power of organization to enforce their ideas. But [illegible] should spread and the attempt be made to fasten the principle upon [illegible]. Who would [illegible] the bill? What would be the result of the effort?

The answer to the question was given by Judge Gary at the recent annual meeting of the stockholders of the United States Steel Corporation. It being the 20th anniversary, Judge Gary reviewed the "principles and policies" of the corporation. He dwelt upon its attitude in being so strongly committed to the "open shop," saying: "The natural and certain effects of labor unionism are expressed by three words: Inefficiency; high costs." And again: "I firmly believe complete unionism of the industry of this country, as attempted, would be the beginning of industrial decay." Perhaps; and yet maybe no more so than would be true of complete domination by capital. However, Judge Gary has given the answer to the question what would occur if the principles and practices of the railroad unions, the building trades unions and the Union Mine Workers were forced upon the entire body of workers. There would be no one left to pay the bill.—From an editorial in Chemical and Metallurgical Engineering.

"Engineering English" Should Mean Good English

References to "engineering English" are found in the editorial columns of both the technical and the lay press, the term being sometimes used in derision and sometimes seriously as if to denote a kind of writing with rules and usages of its own differing from those that apply to the composition of men not engineers. The best way for technical writers to escape the derision is to disabuse their minds of any idea that they should or properly may adopt a distinctive phraseology or method of construction. Apart, of course, from the inevitable use of the established technical terms of their profession, they should employ, with proper discrimination, the ordinary words of the dictionary, and observe, without pedantry, the accepted rules of English—not of foreign—grammar. A specialized vocabulary has by long prescription come to be considered appropriate for baseball reports and stories of seafaring life, but the engineering writer has no need of one. In committing his ideas to paper he should shun the conversational idioms of his professional pursuits equally with the jargon of commerce, the slang of the workshop and the stark uniformity of the hardware catalog. As to catalogs, there are, of course, useful compositions that must necessarily partake of the character of an inventory, but even in these cases skillful handling and the relegation of details to tables and to the legends under illustrations can do much to dispel the curse of dullness.

Good English is good English, whether the topic be literature, history, politics or engineering. The laws of syntax do not vary with a change of profession. The rules of rhetoric remain the same. Debasement of the noble currency of our mother tongue is much to be deplored. It is true that a mathematical thesis does not lend itself to pathos or a treatise on technology to the play of wit. That only makes it the more necessary that the principle of order, which is the first law of composition as well as of Heaven, and the principle of clarity, which is the second, should pervade them. Descriptive engineering articles, on the other hand, permit a forcefulness of presentation, a vividness of statement, even an occasional flash of imagination or touch of fancy, that they all too seldom display. Frenchmen, to whom the art of expression seems a native gift, have probably best exemplified the possibilities that inhere in engineering as a field for literary skill. To most Englishmen engaged in technical pursuits, and in still greater degree perhaps to most Americans, their work itself is so absorbing, the pressure to excel in action so compelling, that they have no time to learn to write. Graceful historians of the engineering arts are therefore in the English-speaking nations neither born, like poets, nor made, like the purveyors of popular fiction. Hence the records of invention and material achievement seldom rise above the threadbare phraseology and commonplace method of a memorandum book, although the facts related may be as far as possible from the threadbare or the commonplace.

[illegible] writers of [illegible] intellectual development, fed in their youth perhaps on the great masters of English who nowadays have fallen into such lamentable neglect, have succeeded in informing the books and papers they have written with an interest more widespread than that merely which inheres in the subject matter, just as a few lawyers have made arguments and a few judges have handed down decisions so lucid in their language, so limpid in their construction, and so shot through with eloquence suppressed or soaring, that intricate causes have taken on a general interest which the routine verbiage of the courts could never have bestowed. Such lawyers are rare, and such engineers unfortunately are rarer still. It would doubtless be demanding too much from human talents to expect otherwise. Yet the wish may be pardoned that our technical colleges would so train their students in the practice of writing that no graduate could compose the paragraphs, crude or redundant in form, ambiguous or obscure in meaning, and freely sprinkled with solecisms, that in some minds have come to be meant by Engineering English.—Editorial in Electrical World.

The Engineer and the English Language

"An engineer who is inarticulate," said a well-known New York engineer in speaking of the value to members of his profession of a thorough knowledge of English, "is quite as useless as one who is professionally incompetent." This, writes Prof. Homer A. Waitt in Composition of Technical Papers, is a terse and vigorous expression of a truth which all experienced engineers recognize, that the man who has not the power to give his ideas clearly to others, the man whose thoughts are locked in his brain simply because he has not the ability to communicate them, suffers under a handicap which no amount of professional knowledge can possibly overcome. The engineer is not a hermit in his profession, shut off from all intercourse with others; his work is indissolubly bound up with that of other men, and he finds himself constantly obliged to communicate with them. The men employed by an electric-light company, from the president down to the humblest clerk, are individuals each busied with his own particular task, to be sure, but each contributing towards a common end—the success of the company, and because of this common aim they are in constant communication with one another, by word of mouth, by letter, by written report. It can, then, be readily perceived that the failure on the part of any individual employee to make himself clearly understood by other employees will often affect very seriously the efficiency of the whole machine. An incomplete, indefinite, or ambiguous report from a foreman, for example, may temporarily delay the progress of an important piece of work. The more clearly and effectively the communication of ideas is carried on, the more efficiently will the common work of all be accomplished. And the employee who is best able to express himself clearly and exactly is the one who will stand the best chance, other things being equal, of advancement. The young engineer who writes the clearest, most accurate report, the foreman who can explain exactly and in a few words just what he wants done, are the men whom the superintendent is bound to notice. There is more than one instance on record of promotions which have come solely as the result of ability to write a good report.

Building Trades Labor and Building Material Prices.—The Southern Pine Association recently sent out a questionnaire to 150 building material dealers in the largest citites and most thickly populated communities of the country. Some of the results of the inquiry as gven out by the Association under date of May 31 follow: A preliminary summary of the first 80 replies shows there is an ample supply of building trades labor. Only 2 cities out of 80 report a shortage; 67 have sufficient labor to carry out their building programs, and 11 report unemployment in this class of labor. There had been reductions in wages in only about half of the cities heard from. The average reduction in wages of carpenters and bricklayers in those cities which have reported decreases is from 15 to 20 per cent. Wages of common labor have been reduced more; 26 cities reporting reductions ranging from 25 to 55 per cent. Nearly all report a marked increase in the efficiency. Light is thrown on the subject of reductions in the retail price of staple building materials, as compared with a year ago.

	Per cent.
43 cities report average reduction on all items of..............	35
37 cities report average reduction on lumber of	47
12 cities report average reduction on brick of	29
19 cities report average reduction on all items, excluding lumber	19

Economic Proportions of Plate Girder Viaducts

By H. J. KESNER,
Associate Professor of Structural Engineering, Purdue University.

In the remarkably complete and illuminating paper on "The Hell Gate Arch Bridge and Approaches," by O. H. Amman, M. Am. Soc. C. E., published in the 1917 Transactions of the American Society of Civil Engineers, appears a comparison of three types of approach viaducts which were given preliminary consideration. Type (a) (see Fig. 1) is the customary steel tower and girder construction; type (b) a design employing plate girders resting on isolated bents pin connected top and bottom and allowing the longitudinal tractive forces to accumulate over several span lengths before being resisted by masonry piers; and type (c) a series of plate girder spans simply supported on masonry piers.

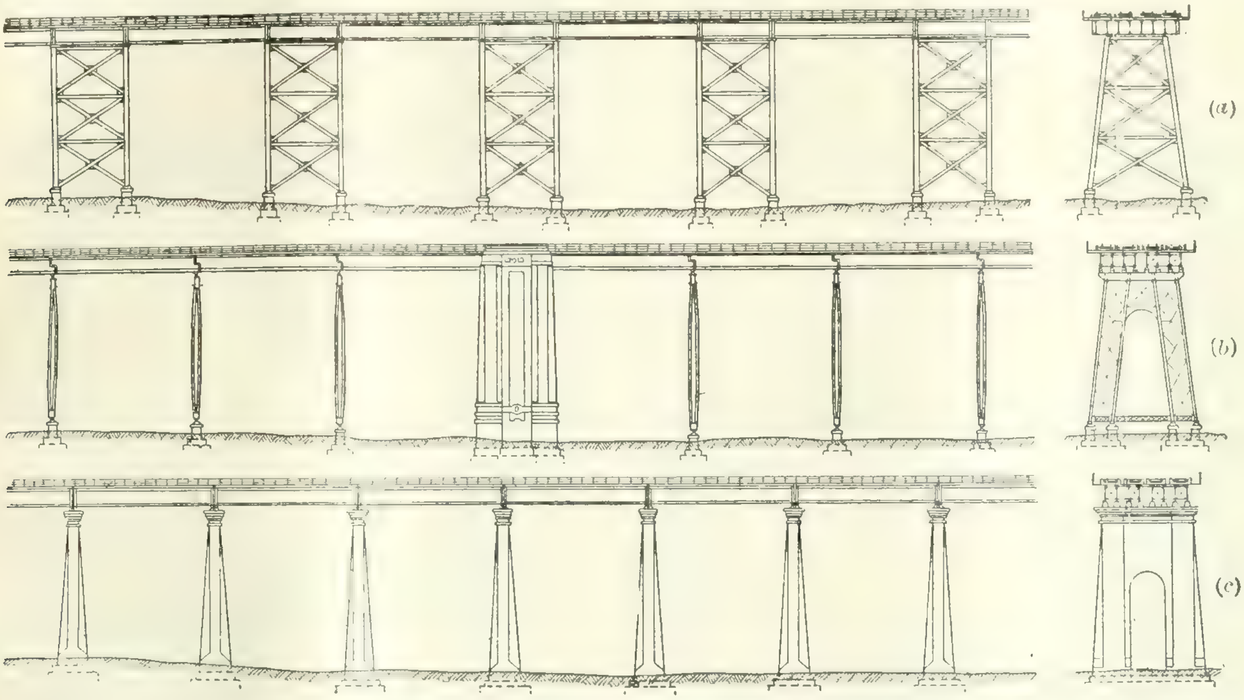


Fig. 1.—Comparison of Three Designs of Plate Girder Viaducts.

The economic proportions governing a type (a) design have been very completely stated in Kunz's "Design of Steel Bridges." From the tables there deduced the economic lengths of both tower and intermediate spans corresponding to a given height of tower may be readily extracted. The economic proportions governing a type (c) design follow the general law developed for simple spans in most standard text books on bridge design, and may be expressed by the formula

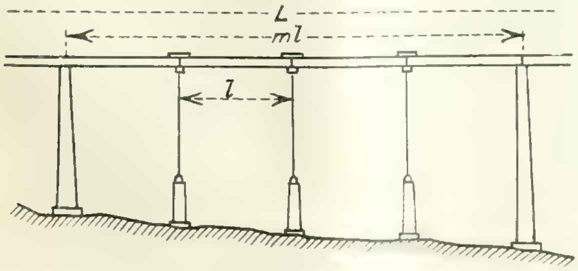


Fig. 2.

$$l = 316\sqrt{\frac{C}{ap}}$$

where l = economic span length in feet
C = cost of one pier in thousands of dollars.
p = cost of steel work in cents per pound.
a = coefficient in the empirical formula ($w = al + y$) for weight of steel work in pound per lin. ft. of crossing.

The writer has undertaken to derive an expression governing the economic proportions of a type (b) structure. The notation refers to Fig. 2 which represents a typical unit of a viaduct of total length L.

Referring to this figure let

A = cost of both end abutments.
B = cost of floor and that part of steel which remains constant (corresponding to the y term in the expression $w = al + y$ above).
C = cost of one pier.
D = cost of one intermediate steel bent with its pedestals.
L = total length of viaduct.
x = number of pier spans.
l = length of span between bents.
ml = length of span between piers.
q = (m − 1) = number of bents between piers.
p = unit price of steel.
p^1 = unit price of concrete.
Y = total cost of viaduct.
$Y_1 = [Y - (A + B - C)]$ = comparative cost of viaduct.
al = weight per ft. of variable portion of girders.

An expression for the total cost of the viaduct may then be written in the form

$$Y = A + B + C(x - 1) + Dqx + Lalp$$

But $x = \frac{L}{ml}$

And therefore

$$Y = A + B + C\left(\frac{L}{ml} - 1\right) + Dq\frac{L}{ml} + Lalp$$

The term D, being the cost of one bent with pedestals must be expressed as a function of l. It may better be represented in the form $D = Kl + C_1l$, expressing separately the costs of steel bents and their concrete pedestals.

Then

$$Y = A + B + C\left[\frac{L}{ml} - 1\right] + \left[Kl + C_1l\right]\frac{qL}{ml} + Lalp$$

Differentiating $\frac{dY}{dl} = 0 + 0 - \frac{CL}{ml^2} - 0 + 0 + Lap.$

Equating the first derivative to zero to give the condition of minimum cost and solving: $Lap = \frac{CL}{ml^2}$

$$l = \sqrt{\frac{C}{map}} = \sqrt{\frac{1}{m}}\sqrt{\frac{C}{ap}}.$$

But $l = \sqrt{\frac{C}{ap}}$ is the expression for economic length in the type (c) viaduct (the change in units of C and p can be taken up by the coefficient of the expression), and m is the number of intermediate spans into which the steel bents divide the space between masonry piers. When $m = 1$ the type (b) becomes the same as type (c).

For purposes of comparison of relative costs when m = 1, [illegible] we may use the value

Y [illegible] Y = (A + B [illegible]

[illegible] of comparative costs per [illegible] foot of viaduct

[illegible] (K + C) [illegible] (A)

[illegible] ml [illegible] m

The [illegible] of the equation may be [illegible] by putting the results in tabular form. We may assume a case as illustrated by Fig. 2 in which the total height of piers is 65 ft., of bents 50 ft., and of pedestals 15 ft. A pier for this case will be considered as containing 500 cu. yd. of concrete and costing $[illegible]. Using a load equivalent to Cooper's [illegible] on a single track span 40 ft. in length the load (dead, live and impact) on a steel bent would be 520,000 lb. and the sectional area of steel required in the columns (at 9,000 lb. per square inch) 57.8 sq. in. or 0.4 sq. ft. The cost of one steel bent would then be approximately at 6 ct. per pound.

490 × 50 × .06 × 0.4 = $588 = Kl

$$K = \frac{588}{40} = 14.7$$ (dollars per lineal foot of viaduct)

Giving the pedestals 120 sq. ft. of bearing area on the soil and using a unit cost of concrete of $12 per cubic yard or $0.445 per cubic foot, the cost of the pedestals corresponding to one bent becomes:

120 × 15 × 0.445 = $800 = [illegible] l

$C_1 = 20.$

Table I may now be built up showing the comparative values of $\frac{Y}{L}$ for different values of m, by successive substitutions in equation (A).

TABLE I

[illegible]	[illegible]	l	ml	[illegible]	[illegible]	C	K	Y/L
[illegible]	1.000	89.5	89.5	12.5	[illegible]	[illegible]	14.7	154.00
[illegible]	.707	63.3	126.6					112.30
[illegible]	.577	51.6	154.8					100.50
4	.500	44.7	178.8					93.00
[illegible]	.448	40.1	200.5					87.70
6	.408	36.5	219.0					83.70
[illegible]	[illegible]	33.8	236.0					80.40
10	.316	28.3	283.0					73.60
15	[illegible]	23.1	346.5					66.80
15	[illegible]	26.6	400.0	12.5	8000	20	19.4	76.50

As m increases the first and third terms of equation (A) decrease. Apparently the cost decreases continuously as larger values of m are employed. Practically, of course, as the distance ml grows larger the piers must be increased in size to take up the larger tractive forces and C cannot remain constant. Also, as m increases, l decreases and smaller steel bents are used; but there is a limit below which the size of the bents may not be carried since a certain minimum amount of metal is necessary to maintain a suitable $\frac{l}{r}$ factor in the columns regardless of the load. In the present numerical example, with steel columns 50 ft. high the minimum section would be approximately 25 sq. in. in each column.

If we recompute the tabular quantities for m = 15, with revised values of C and K the comparative cost per lineal foot of viaduct rises to a figure comparable to that for m = 10.

It is interesting to note that in the type (b) viaduct as developed in the preliminary design for the Hell Gate Arch approaches it was proposed to resist the longitudinal forces from braking and traction "about every tenth span." The final column of our table giving comparative cost per lineal foot of viaduct shows that a value of m = 10 places the cost in the region of the minimum, although it is hardly practicable from the nature of the variables involved to arrive at an absolute minimum figure.

The writer presents the general formula

$$l = \sqrt{\frac{1}{m}} \sqrt{\frac{C}{p}}$$

as an extension of the common formula $l = \sqrt{\frac{C}{ap}}$ for simple spans in the belief that it offers a method of approaching the problem of economic proportions of a type (b) viaduct.

A Plan for Reducing Unemployment in the Building Industry

In the April Bulletin of the Master Builders' Exchange of Philadelphia, Mr. D. Knickerbocker Boyd, an architect of that city, offers the following suggestions for lengthening the period of employment in the building trades in Philadelphia: A group congress or tribunal should be organized to consider all problems connected with building and related construction. The group would include realtors, architects, engineers, builders, sub-contractors, material men, working men, and the final owners or tenants. This group should act as a central bureau through which, voluntarily, all construction programs should be cleared including national, state, municipal and private work in this territory. Suggestions could be made for co-ordination of activities, allocation of materials, and reduction of estimating costs. Local production could be encouraged, rail hauls shortened, traffic congestion lessened, a constant labor survey could be maintained to the advantage of employer as well as employe, good management promoted, efficiency encouraged, apprentices attracted to the trades, educated and properly trained and increased production would result all around.

In such a program the vital necessity is also to educate the public to a sensible distribution throughout the year, of its construction demands and requirements. This applies equally to city work, industrial construction, semi-public buildings, residences and household repairs and maintenance.

Instead of crowding the main construction work into seven or eight months that which could possibly be deferred and done during the remaining five months should be so scheduled.

Owenrs making inferior alterations or slight additions to buildings should be encouraged to have such work done in the "off-peak" season. Old buildings demolished to make way for new ones should be torn down in cold weather in advance of the new construction without being done as is so often the case at the time when the new building itself ought to be under way.

Existing office buildings, commercial establishments and similar structures should be painted outside and refinished inside at times when painters are least busy on new work.

The same argument applies to the paper hanging and refinishing of apartment houses where another element enters, namely the termination of leases. It has even been suggested to realtors that the leases be staggered in dates instead of falling with such unanimity on Oct. 1st of each year.

Householders, insteading of having spring housecleanings or fall housecleanings, would find it advantageous to be more constantly and less periodically "cleaned" so that paper hanging, painting, plastering and other needful work could fall on the workers like the gentle, steady rain instead of in downpours with subsequent dry spells. Wiring of old residences for electricity might well be done in January, February and March when electricians are usually out of work on new construction.

Surveys should be made of all structural requirements of Philadelphia and vicinity and of all trade conditions of unemployment and the two fitted together in the very best manner possible. It will be necessary to educate and inform the public as to the needs and advantages of its co-operation in such a program. Civic clubs and others will afford good forums and it may be advisable to advertise. Certainly the necessities of the occasion must be forcibly and frequently presented. The public will surely respond.

After it overcomes some prejudices and breaks some habits it will place orders with the heating contractors in the spring to have its apparatus and flues attended to "some time" during the summer instead of waiting until the last moment in the fall.

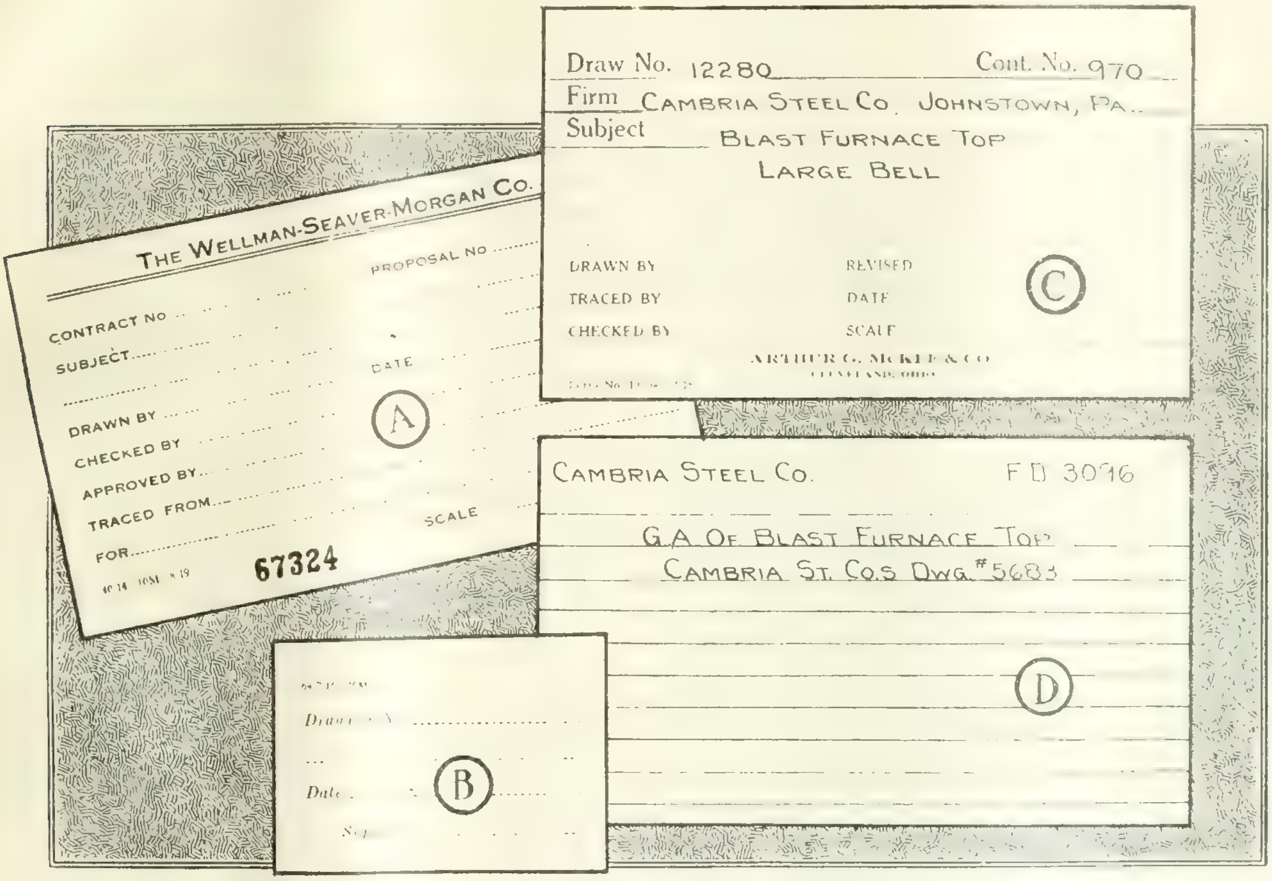
The public will appreciate having its attention forcibly called to the fact that by complying with common-sense requirements, if not with ordinances, and having covered metal containers for the ashes from every household it will afford employment to the metal workers in their off building season, while at the same time lessening fire and life losses, street litter and disease.

Other instances might be cited applicable to the carpenter, the slate-roofer, the stone cutter and other trades, the most difficult to provide with off-peak employment being the bricklayer. But through proper coordination of public and private construction, scheduling of interior work, sewer construction, boiler setting and other vocational opportunities his, with all the other trades, can be greatly benefited.

Systems for Indexing and Filing Drawings

The indexing and filing of drawings is one of the most complex problems of the drafting room. The systems for handling this work used by five prominent engineering and manufacturing enterprises were described by Mr. L. H. Park, chief draftsman, Arthur G. McKee & Co., Cleveland, O., in a paper read March 8 before the Cleveland Engineering Society. The matter following is taken from the paper.

Five large engineering enterprises: The Wellman-Seaver-Morgan Co., the Grasselli Chemical Co., the Koppers Co., the Austin Co., and Arthur G. McKee & Co., have what to their minds are nearly perfected systems, adapted to their individual lines of work. All use their tracings for reference, except the Austin Co. and the Koppers Co., who use both tracings and blue prints. In all cases the drawing sizes are approximately the same, each having the full half and quarter sizes. The Wellman-Seaver-Morgan Co. has one size smaller, which is about one-eighth size, this being used for drawing room standards or details of parts which can be used variably.



THE WELLMAN-SEAVER-MORGAN CO.
PROPOSAL NO
CONTRACT NO
SUBJECT
DATE
DRAWN BY
CHECKED BY
APPROVED BY
TRACED FROM
SCALE
FOR
67324

Drawn
Date

Draw No. 12280 Cont. No. 970
Firm CAMBRIA STEEL CO. JOHNSTOWN, PA.
Subject BLAST FURNACE TOP
LARGE BELL
DRAWN BY REVISED
TRACED BY DATE
CHECKED BY SCALE
ARTHUR G. McKEE & CO.
CLEVELAND, OHIO

CAMBRIA STEEL CO. F D 3096
G.A. OF BLAST FURNACE TOP
CAMBRIA ST. CO.S DWG. #5683

Index Cards for Keeping Track of Drawings and Tracings. (A) and (B) Cards Used by Wellman-Seaver-Morgan Co.; (C) and (D) Cards Used by Arthur G. McKee & Co.

System of Manufacturer of Heavier Chemicals.—The system of the Grasselli Chemical Co., manufacturer of the heavier chemicals, has been developed to suit its particular requirements. Its drawing records cover buildings and equipment for chemical manufacture in industrial plants and also the drawings of warehouses and other equipment. This is what may be called a direct system, where chief reliance is placed upon the drawing files themselves rather than upon going through the regular channel of looking up a drawing, topically or numerically, in a card, or similar, index and then going to the drawing file.

When a drawing is wanted the file clerk needs only to know what works or warehouses and what departments are called for. Then he goes directly to the drawing file where this work's drawings are filed and he is able without delay to find the particular folder in which this drawing is located. It is then a matter of a few seconds to find the drawings. Briefly, the plan is as follows:

The files are first subdivided into works, warehouses, laboratories, etc. In the case of warehouses, where a large number of drawings is not required, one folder is sufficient. For a large plant or works where there are a number of different departments manufacturing different products, files are provided for each department. When the number of drawings in any department becomes too great for one file, subdivisions are made under subtitles of "buildings," "equipment," etc. A record is kept of the drawing numbers as allotted. One main number is given for each file and then the sheets are numbered numerically as allotted. For instance: The file may be given No. 5000, and as drawings are made they are numbered 5000-1, 5000-2, etc. In grouping the drawings after completion, all drawings numbered 5000 would be grouped in the one file.

The Graselli company's custom is to file the tracings in folders for reference use. This is not a common practice, but its experience has been that the tracings stand this kind of service very satisfactorily, eliminating the necessity of having an extra set of blue prints and doubling up the file capacity. In addition to the tracings, study drawings and blue prints of outside manufacturers, who supply machinery and other equipment, are included in these folders so that the folder for a department becomes a complete record. No topical record is kept of the drawings in books, cards or otherwise—the only record kept outside of the drawing files themselves being a numerical record on which the titles of drawings are kept and the dates when made as the numbers are assigned to the drawings and files. It is the practice, in addition to general reference files which are kept in the drawing room, to keep a complete set of all blue prints in a vault. These blue prints are filed in a manner similar to the regular drawing files, although lack of space at the present time prevents this. Vault records are kept at the Cleveland plant, which is about three miles from the downtown office, and this makes it impossible to use the vault blue prints for reference. Altogether they have about 1,300 drawing files and 45,000 drawings.

System of Builder of Heavy Machinery.—The Wellman-Seaver-Morgan Co., builder of a widely varied class of heavy machinery, uses the following system:

One man has charge of the filing and indexing on account of the great number of tracings and the limited amount of filing space. The large tracings are filed in drawers which will accommodate 200 sheets. Drawers for half size tracings are partitioned to contain two sheets, and cross partitioned for quarter size to contain 800 sheets. All sheets are filed numerically, which necessitates considerable care in removing and filing those tracings which are near the bottom of the drawer. They have adopted a plan for filing the eighth size sheets which is very good. These small sheets are placed in folders and filed vertically in long, deep drawers which make it very easy to remove and file. The wear and tear on the tracings is reduced to a minimum.

The indexing is by the card system. In the lower right-hand corner of the drawing is the title block containing the contract number, title of drawing and drawing number. A card (A, see illustration) is filled in with the same information as appears in the title block and is filed under the contract number. Entrance is also made in a drawing record book in which the numbers run consecutively regardless of contract. Opposite the number which corresponds to the number on the drawing is entered the title of the drawing, the date the drawing is made and the contract on which it applies.

The system is carried further by indexing the parts on a drawing. For example, suppose there is a 3x6-in. bearing bracket detailed on the drawing, the clerk in charge of this card index would sketch the bracket on a card and file it under the head of "bearing bracket" and in a subdivision under "3 in. dia." This card is 3x5 in. and has recorded thereon the drawing and pattern numbers. This index is used to prevent duplication of patterns.

After ascertaining the drawing number from the card index, a slip is made out by the party desiring the tracing (B) having thereon the drawing number, the party's name and the date. This slip is filed in the vault when the tracing is given out. These slips are filed numerically in a rack. When a tracing is not in the file the file clerk can tell immediately where it is.

System of Engineer and Contractor for Coke Oven Plants.—The system adopted by the Koppers Co., Pittsburgh, engineer and contractor for complete by-product coke oven plants, during the war and still in use, is well worthy of note. This company, employing between 300 and 400 draftsmen and making several hundred drawings per week, needed the most efficient system that could be worked out.

All tracings are filed numerically in a central vault. A complete buzzer system is provided, buttons being located on every third or fourth drawing table with the indicator inside the vault. Office girls act as carriers. When any party in the drawing room desires a tracing he makes out a slip, similar to that used by the Wellman-Seaver-Morgan Co., and presses the nearest buzzer button. A carrier calls for the slip and delivers the tracing. Should the tracing be in use, the possessor either allows it to be taken or advises about when it can be obtained. If the time is too long for the other party to wait he is given a blue print, several of which are always kept on file. His requisition slip is then changed to read "blue print" instead of "tracing." A complete and reliable check is kept as to the location of tracings and prints at all times. When a change or revision is being made on a tracing, the vault is informed and immediately all prints from that particular tracing are destroyed. All tracings are collected nightly, placed in the vault in bundles having attached thereto a tag bearing the party's name. These are delivered to the respective parties the next morning.

System of an Engineer and Contractor for Industrial Buildings.—The system adopted by the Austin Co. has been developed to meet the needs of the main office and each of its branch offices. In some cases the branch offices are primarily sales offices while others have their own engineering departments. As each of these departments operates under the general engineering department, it is necessary that the engineering and filing of drawings be well systematized. For other reasons, such as standardization of buildings together with their many details, it is proper that the reference drawings be in blue print form.

For work that is primarily standard, special filing cases are used for containing standard prints for individual drafting room requirements. Similar prints are placed in special folding cabinets in the sales offices; all of these prints are filed flat and in groups of about one dozen and hung in a vertical position in racks. No card system is used for indexing these drawings as they are filed numerically according to the standard building to which they pertain. Should any draftsman require the use of these drawings it is his privilege to remove them from the rack without inserting a card showing their removal. This is not true, however, for other than standard drawings. For these a general card index system is used. All drawings are numbered and indexed according to contract number and the serial number according to the classification of the work involved—for example, general drawings, structural details, heating, lighting and equipment drawings of certain numerical numbers which immediately indicate the purpose of the drawing in queston.

For the large contracts which require a number of drawings and the likelihood of furnishing blue prints to various departments, as in a case of revision, a complete record is made on a form sheet on which is shown the record of drawings, their numbers, date of approval, record of prints furnished, revisions and other necessary information for each job.

Because of the great variety of work performed in the various drafting rooms the preparations of drawings are made according to which department they are to serve.

The development department takes complete charge of any new standards or other drawings to be used by all departments such as engineering instructions as they pertain to design, estimating, construction, sales, etc. The indexing and filing of all drawings included in this department are maintained and controlled exclusively by this department. Blue prints of drawings thus prepared are sent to the various departments for their files. Obsolete drawings, if any, are replaced correspondingly.

The material sales department controls the engineering pertaining to buildings sold for shipment and not for construction. This department maintains the indexing and filing system somewhat along the lines of the other departments mentioned, but is different in many respects, particularly as to the lettering and numbering of drawings. Like other departments, information serviceable for district offices is supplied to the general department for the proper filing and relay according to their instructions.

The sales offices are supplied with vertical cabinets for filing blue prints according to contract or job numbers as well as the standard drawings which are supplied by the general department. These drawings are numbered numerically for each contract and, except for very large jobs, it is not necessary to maintain the card index system. The cabinets are so arranged that the front part is a folding drawing table and when entirely closed can be used for a side table as office furniture; too small, however, for a reference table.

The engineering departments in the various cities have separate filing systems for their own jobs as well as for drawings received from the general department and standard drawings furnished by the development department, the card index system, mentioned before, being used for the records.

In each of the engineering offices there is a vault with cabinets of the drawer type for filing current drawings, including those up to one year old, since the buildings are guaranteed for one year. Ample filing space is allowed for drawings until this period expires.

In addition to these filing cabinets, there is a reference room of sufficient size and with proper reference tables for general use. This eliminates the removal of many drawings from the drawing room. After drawings are returned for filing they are placed in a drawer specially designated for this purpose from which the filing clerk takes them to their proper file.

A separate card index system and other records are kept for drawings of finished jobs or others which are to be filed in the permanent storage in the vault. These drawings likewise are placed in cabinets of the drawer type, the folders in each drawer containing not more than 20 tracings. Blue prints are filed in separate filing cabinets in a similar manner.

In case a tracing or blue print is removed from the vault, a special card which records the removal is placed in the filing cabinet. The placing and removal of these drawings is handled by a special filing clerk. Foreign drawings are handled and recorded similarly except that the drawings are filed according to the job unless they are standard or general drawings serviceable for other jobs, in which case they are filed in special cabinets for the purpose, cross index filing system being used. The work of supervising the issuance and maintenance of the indexing and filing systems comes under the jurisdiction of the chief draftsman.

System of an Engineer and Contractor for Blast Furnace Plants, Steel Mills, Etc.—The system in vogue with Arthur G. McKee & Co., engineers and contractors for complete blast furnace plants, steel plants, sintering plants, etc., is practically the same as that used by the Wellman-Seaver-Morgan Co. as regards the filing of tracings except that only half the number is filed in each drawer. At one time McKee & Co. were cramped for filing space; tried filing tracings the same as the Wellman-Seaver-Morgan Co., that is, 200 full-sized tracings per drawer, etc. They found, however, that the tracings were depreciating so rapidly that steps were immediately taken to double the file capacity.

They use three colors of cards for the tracing index; all cards being of the same form (C, see illustration), yellow cards for the contract index, white cards for the subject, or title, index and blue cards for the client index. When work on a new contract is started in the drawing room, a blue card is filled in, giving name and location of the client and a description in general of the work.

When a draftsman begins work on a drawing, he will go to the card index and take out two blank cards, one yellow and one white, each of which has the drawing number stamped thereon, fill in the client's name and location or where work is to be done and the title of the drawing. These two cards travel with the drawing until the check print is made, at which time they are filed under contract number in the unfinished index. When the checker has signed the drawing he takes the two cards from the unfinished index, signs both, attaches them to the tracings, where they remain until detached by the chief draftsman when ordering prints for the purchasing department. Cards are then filed in the finished drawing file by the file clerk.

All who use the title or topic index have undoubtedly had more or less trouble at times in locating drawings by title. McKee & Co. have an iron-clad rule that all titles must be edited by the chief draftsman, the idea being to make them as concise and descriptive as possible, in order to reduce to a minimum the possibility of misfiling index cards. When an existing drawing is reused, a yellow card, not having a drawing number thereon, is filled in complete, including the number on the drawing. The new contract number is then added to the existing white or title card. A drawing record book, similar to that of the Wellman-Seaver-Morgan Co., is also used—as a numerical index only.

Foreign prints, or clients' and manufacturers' prints pertaining to a contract, are filed in individual drawers while the contract is alive. When the contract is finished they are cross indexed for subjects and client or manufacturer and placed in a permanent file. Plain ruled white index cards are used for these prints. (D, see illustration.)

For ready reference to standard parts McKee & Co. use the scrap book system. The scrap book is a large pasteboard binder having at the hinge a number of gummed edges to which blue prints are attached and will accommodate about 50 large size prints. These books are filed in a horizontal compartment case, each compartment holding four books. Contents of books are plainly marked on the hinge.

Because the vault is located centrally in the drawing room, the draftsman, after ascertaining the drawing number, will go there and help himself. If, however, the number is unknown, he will write on a slip of paper the information necessary to find the number from the card index; give this slip to the file clerk, who will deliver the drawing.

National Building Exposition to be Held at Cleveland.—A national building expostion, conducted by the men of the construction industry, will be held at Cleveland, O., the coming fall. The management of the show is in the hands of a special corporation formed by men of this industry—lumbermen, brick manufacturers, building supply men, contractors, architects, electrical, heating and fixture men, realtors, bankers and others who are active in the construction industry. Ralph P. Stoddard secretary-manager of the Common Brick Manufacturers Association of America, who managed the first Cleveland Complete Building Show of 1916, is director general. The exposition will be the first in Cleveland's new $5,000,000 public hall. Edward A. Roberts, Secretary Builders Exchange of Cleveland, Rose Bldg., Cleveland, is secretary of the exposition.

Some Union Labor Abuses in the Building Industry

Herewith we quote in full a paper presented by Mr. Charles R. Gow at the March 24 meeting of the Boston Society of Engineers under the title, "The Responsibility of Organized Labor for the Stagnation in the Building Industry."

The remarks which I shall make to you upon this subject are not directed against the fundamental principles of labor unionism, but rather are intended to be in the nature of a somewhat frank criticisms of certain unsound practices on the part of many unions which have resulted in very serious economic consequences to the building industry of Boston.

Intolerance Hampers Labor's Friends.—I am aware that one may not in these days raise his voice in protest against any act or motive of union labor without being promptly classified by the labor group as an avowed opponent of the entire labor movement.

Intolerance on the part of labor spokesmen toward the opinion of others and their heated and often bitter resentment of all criticism have rendered it extremely difficult for true friends of labor to counsel moderation or to urge measures for labor's ultimate welfare.

Advantages, Disadvantages and Morals.—It is my judgment that there may be several advantages both to the employer and to the public in dealing with labor unions which are intelligent and responsible in their conduct and practices. When, however, the obvious disadvantages of such dealings outweigh the benefits to be derived therefrom, there is no compunction, either legal or moral, which requires the community at large to subordinate its interests to those of organized labor.

If an act is wrong at all, it is just as wrong when commtited by a labor union as it would be if done by a highwayman or any other evil person.

The Author's Experience.—During the war I served as an army officer in charge of constructing the Army Supply Base at South Boston. This project entailed an expenditure of, approximately, $24,000,000 and the employment of a maximum of 7,500 workmen. Under the terms of the so-called Baker-Gompers agreement, this work was carried on as a closed shop job and in conformity with the working rules and agreements of the several trades unions employed in its construction. As a consequence, I received a very liberal education in the aims and policies of the unions as applied to the building industry. This experience, somewhat amplified by later contact and study along similar lines, has rather alarmed me as to the future welfare of the building industry in this locality, provided some of the present tendencies are not checked, and I shall try to present to you, as briefly as possible, an outline of the situation as it appeals to me.

Labor, Material, and Restraint of Trade.—It is customary to consider the cost of a building as being made up of the cost of the materials delivered at the site and the cost of labor used in assembling these materials in the completed building. Strictly speaking, however, there is no such thing as materials, unless we refer to the raw products in their natural state in the ground or in the forest. That which we speak of as material is merely the result of the combined labor which has gone into the production, manufacture and transportation of these raw products. True, a portion of the labor is contributed by the owners of the mine, of the mill or factory, of the railroad or by the distributor, and it may also sometimes be true that the wages paid to these owners in the form of so-called profits are in excess of a reasonable return for the amount and character of service rendered.

However, numerous laws have been established which prohibit employers such as those referred to from combining into unions for the purpose of fixing their wage or profit, or of agreeing upon conditions under which they will render service. These laws, like all other laws, are sometimes evaded; but in the last analysis, by and large, the wages of this employing class are absolutely regulated by the immutable natural laws of supply and demand.

With respect to direct labor, however, the laws are much more generous. The right of paid employes to form unions for the purpose of fixing profits in the form of wages and of regulating conditions of employment is legally established and recognized.

This distinction between the two groups is of passing importance. We prohibit combinations by employers because [illegible] that such action might [illegible] to the public [illegible] through the increase and [illegible] of profit and [illegible] consequent advance in cost of the commodities which [illegible] On the other hand [illegible] and even encourage the wage-earning class to do the self-same thing [illegible] respects they have [illegible] of their opportunities. The economic effect upon the general public is the same in either case, whether costs be increased by combinations of employers or of employes.

There would seem to be no good reason why both groups should not be permitted to organize for their mutual protection and interest, but there is no moral right, and there should be no legal right, which would permit either group to combine for purposes which are detrimental to the interests of the community at large.

Labor the Great Item.—Statisticians have estimated that, on the average, at least 75 per cent of the cost of materials delivered on the site is on account of direct labor. Assuming this to be true, then at least 80 per cent of the cost of the completed building is represented by the direct labor item. Any general influence which increases labor costs must necessarily be reflected in a corresponding increase of the proportion in the cost of the completed building. On the other hand, if any substantial reduction is to be made in the cost of building construction, it must come chiefly through a readjustment of the 80 per cent item.

There has been a tremendous increase in labor cost during the past six or seven years. This increase has resulted from two principal causes, namely, increased rates of pay and decreased efficiency on the part of the individual worker. Such pay increases as have occurred have probably been justified in a large measure by the depreciated value of the dollar. Just why the same logic does not apply in the reverse order of things is one of the puzzling problems of the present situation which as yet remains unanswered.

The Reduction and the Rise in Efficiency.—The decrease of efficiency which has been especially marked during the past two or three years is likewise the result of two separate causes. First, the excessive demand for labor during the period of its maximum shortage produced a certain feeling of independence among the workers which was bound to result in more or less disregard for the wishes and welfare of the employer. It might also be said in passing that this attitude was not characteristic of any one class of employes but was noticeable generally wherever help was employed.

However, the inefficiency which resulted from this cause very largely disappeared some months ago with the advent of the present industrial depression and as unemployment became more general. It is safe to assume that no further trouble may be expected from this particular cause until the law of supply and demand again enthrones labor on its former pinnacle of prominent industrial importance.

The second and more serious cause of inefficiency is artificial, union made, and is in defiance of all economic laws and public welfare as well. It is with regard to this feature that I wish to devote my principal attention.

Closed and Open Shop.—Until within a comparatively few years the building industry of this vicinity was represented by both closed and open shop contractors, so that there existed a certain degree of competition which prevented excesses by either group.

The superior organizing ability of the union leaders, backed by a strong public sentiment in their favor, led to the gradual elimination of the open shop contractor with the result that organized labor through the closed shop now holds practically a monopoly over the entire industry.

As a result of this situation, a non-member of a union cannot today find employment in a building trade in Boston except to a very limited extent. Consequently, practically all such men as a matter of necessity have joined the union pertaining to their trade because the closed shop jobs constitute their only sources of employment.

A non-union or open shop contractor from another city cannot work in Boston because he is unable to secure his supply of labor here, such labor having been absorbed by the unions [illegible]

Individual contractors who might be inclined to change from closed to open shop conditions may not do so because, unless they could offer their men permanent employment (and this is not practicable), it would be unwise for their employes to leave the union and thereby restrict their opportunity for obtaining work to but one employer.

Also, general contractors are dependent upon sub-contractors, such as the plumber, electrician, steam-fitter, etc., for work pertaining to those trades and union sub-contractors would not be permitted to do work on an open shop job.

As a consequence of the monopoly thus established by organized labor in the building industry in this locality, there have been developed many practices of an arbitrary and autocratic nature which have seriously affected the interests of employers and public alike, and which if continued will tend to destroy the idustry itself.

Making More Jobs.—It has long been held by leaders of organized labor that whatever makes for the employment of a greater number of men is of direct benefit to the union, regardless of the method employed to secure the result, because it reduces the available supply of men and thereby produces a shortage for subsequent jobs, which in turn enables the union to dictate to a greater extent the terms under which their men will work.

One of the most common means adopted by the unions to force the employment of more men is the restriction of output by agreement. Thus, it was testified to by a number of reputable builders at the recent Chamber of Commerce hearings that although brick masons formerly laid from 1,500 to 2,000 bricks per day it has now become the custom in that trade to limit each man to not more than 500 bricks per day. This greatly reduced output per man has so affected the available supply of brick masons, that during the past year contractors have been obliged to bid as high as $1.25 to $1.35 per hour to obtain their services at all, even though the established union rate was but $1.00 per hour.

At a rate of $1.35 per hour and a daily output of only 500 bricks laid, it will be readily apparent that it cost $21.60 per 1,000 bricks laid for the mason's time alone, exclusive of helpers or material. It is interesting to note that this price is substantially the same as the cost of brick at the kiln. In other words, the union brick mason receives as much money for the simple act of picking up a brick and placing it in the wall as does the manufacturer of the brick for the entire expense of excavating the clay, moulding and burning, handling and storing, including all overhead expense, interest and depreciation charges, bad debts, business risks, etc. Still, labor leaders have been loud in their condemnation of the brick manufacturer as an alleged profiteer.

All Lose but the Extra Man.—As a net result of this campaign by the union for a reduction in output, the cost of the mason's time in laying brick has increased from about $2 per 1,000 to over $20, although the individual mason received but slightly more than double his former wages per hour.

A recent demand of the wood lathers specifies that 12 bundles of laths shall constitute a day's work. For the past few years 16 bundles have been the average output and formerly 30 bundles per day was not an unusual output.

It was formerly the custom among many contractors to sublet various portions of the work to the workmen direct. Thus, the laying of brick, the applying of lathing, plaster, paint, etc., was frequently done upon a piecework basis. The men who undertook this work competed for it on a price basis and naturally exerted themselves to the utmost to produce the maximum of output and therefore of remuneration. This practice has long since been prohibited by the several unions under penalty of a heavy fine for violation, the theory being that the increased production which resulted under this system deprived other union men of an opportunity for employment.

Another method which has been found by the unions to be efficacious in creating additional jobs for their members, has been the simple expedient of insisting that high priced skilled mechanics must be employed to do certain work which otherwise would naturally be done by unskilled labor and in some cases even might require no labor whatever.

Union Dictation.—Having secured complete mastery over the employers through this strategic position it has been a simple matter for the unions to dictate the entire labor conduct of the industry. Each union today has its so-called working rules which form an integral part of the written agreements which employers are obliged to accept if they expect to obtain the services of members of that union. These rules prescribe in more or less detail the requirements which must be observed by the employer and limit to a considerable extent the amount of service which a member may render.

The Foreman's Authority Taken.—While each union has its own particular rules, many of the provisions are more or less common to the great majority. Thus, substantially all such rules require that foremen shall be members of the unions in question. The effect of this provision is to subject the foreman to two conflicting influences. If he is loyal to his employer, he may be deemed offensive to his union; and if he satisfies the union, it very often is because he has been disloyal to his employer.

Formerly, a foreman was the recognized mouthpiece of the employer and assumed all the responsibilities and functions of the latter during his absence. He was charged with the duty of obtaining a satisfactory degree of service from all of the employes under his direction. The employer looked to the foreman alone for results and the foreman in turn exercised full authority over his men.

The relationship has been greatly altered in recent years by this requirement that foremen must themselves be members of the unions pertaining to their craft and have, therefore, to be acceptable to the other members of the unions who are to work under them. In case a foreman for any reason becomes obnoxious to the men, a complaint is filed against him with the union officials and he is tried, not by a group of fellow foremen, but by members selected from the rank and file who have authority to recommend his suspension or expulsion from the union.

During the construction of the Army Base work a foreman's union card was taken from him and he was debarred by the union from further connection with the work. Upon inquiring of the union officials I was informed that the charge heard against him was that he used profanity to the men. It appeared that his case had been considered by a secret tribunal which had recommended his expulsion and the findings were approved by the union membership. The records showed that he was one of the most efficient foremen on the work in the matter of low production cost and satisfactory workmanship. It seemed clear to me at the time that he had been thus disciplined because of too much insistence upon results from his men.

The Trade rules of the Carpenters' District Council provide as follows:

"While all foremen should prove their efficiency as such, they shall not rush, use abusive language or otherwise abuse workmen under their direction. A violation of this rule is punishable by a fine, expulsion from the job, or both."

A Union Foreman's Opinion.—A prominent Boston contracting concern wrote to one of its foremen requesting a report as to why his work was costing so much and proceeding so slowly. The foreman's reply, in part, in his own words, was as follows:

> In regards to a foreman in any trade belonging to a Trade Union it has a tendency to take away his authority, and he has not the control over the men that he would have if he did not have to be one of them
>
> He should be allowed to pick out and discharge his poorest men at any time, even when he is taking on more men, and should not always be afraid of getting in wrong with his "Local," and having a fine put on him, which under the present conditions, they can do. That is one of the reasons that workmen of today are not doing a day's work, simply because they do not have to, and under the present conditions it is impossible to speed up the work with a Union Foreman in charge.
>
> On about all work, there has always been a feeling of dissatisfaction among some of the men, that they were not being used the same as the others.
>
> As there is always some undesirable work to perform, and you would naturally pick out your poorest men to do such work, the consequences are, complaints are taken to the "Local" and then your foreman is called down again, then again, when your poorer men are put to work with the others in almost all cases your work slows down to your slowest men, and until you can control such men, to grading them with a sliding scale, this trouble will always exist.

A Few Unreasonable Requirements.—The rules of the Plumbers' Union provide that—

It shall be the duty of all foremen to report any man late on the job to his employer at the time it occurs.

This rule appears to be commendable in its nature until it is explained that the union insists that, inasmuch as this is the only express stipulation of its kind in the rules, it therefore follows that the foreman can report only this infraction and no other to his employer.

A foreman in the Painters' Union is prohibited from commenting as to whether a man is doing a proper or improper amount of work.

The Plumbers' Union rules provide that no man may be employed as a superintendent who for any reason is in bad standing with the union, although the superintendent is not necessarily required to be a union man.

The electricians and the lathers both submitted demands Jan. 1, last, requiring that on jobs employing three or more men a foreman shall be employed or at least one of the men should receive a foreman's pay.

Another matter which has been taken from the employers' control by the unions is that of selecting and employing apprentices in the several trades. Young men desiring to learn a trade in former years were accustomed to apprentice themselves to an employer who undertook to train them and eventually fit them to serve as finished journeymen. This system some years ago became offensive to the unions because it was believed that too many journeymen were being educated for the welfare of the union. Also apprentices were used for many of the simpler duties to the exclusion of union journeymen. Therefore the unions ultimately insisted that apprentices should be furnished only through the unions.

Since this time many rules have been established by the unions regulating the selection, employment and work of apprentices. The general tendency has been to restrict greatly the allowable number of such apprentices and to select them with regard to their union proclivities and affiliations.

A tendency of recent years on the part of the unions has been to prescribe rules governing payment for all expense of travel when men are sent out of town and, in addition, all board and expenses. The time of reporting for and leaving work is also covered by a great variety of rules.

Prohibiting Efficiency.—There are several rules which prohibit work being done in the most economical manner.

Thus, it is provided by the Plumbers' and Steamfitters' Unions that all piping up to 2½ in. in diameter must be cut on the job by hand. It would, of course, be very much cheaper to have all of the piping cut to exact measure in the shop, using power machines for the purpose, or even to cut it on the job using power, but this is absolutely prohibited by the rules of these unions.

The ornamental work in plastering was once cast in moulds at the shop and erected as units by the plasterers. Now the union requires that all of this work must be run in place by hand work

Paint spraying machines have recently been invented which may be effectively used for painting flat surfaces. Government tests have demonstrated their efficiency and cheapness as compared with hand painting. The rules of the Painters' Union, however, prohibit their use.

The Painters' Union also prohibits the use of a brush more than 4½ in. wide in applying paint by hand.

The Plasterers' Tenders' Union specifies the particular size of hod it will use and also requires that no bag material shall weigh more than 100 lb.

The evident intention of the rules just referred to is to make work for more men regardless of economic considerations.

Skilled Men for Low Grade Work.—Another group of rules is aimed to compel the use of high-priced skilled mechanics to do unskilled work which any intelligent laborer might do.

For example, plumbers must handle all plumbing materials after they have been delivered on the first floor. An employer might prefer to lift the bath tubs for the upper stories by means of a derrick, but the rules provide that they must be handled by plumbers.

Automatic electric pumps are frequently installed for permanent drainage of subways and deep basements, and are found to require only occasional inspection for oiling. On a construction job, however, such a pump requires the constant attention of a union engineer at $1 per hour.

Similarly, a small gasoline driven diaphragm pump of the type formerly operated by hand now requires a union engineer, although any intelligent water boy is competent to do the actual work required of him in addition to his other duties.

Pay for Work Not Done.—A steam operated derrick engine on a certain job properly required a hoisting engineer. An electrically driven concrete mixer on the same job did not necessarily require a skilled engineer, but employed one nevertheless. On the same job there were two other machines installed, a cable drum electrically operated for hauling [illegible] and a small air compressor [illegible] electrically driven to furnish air for some jack hammers.

The union temporarily could [illegible] for the two latter machines, but provided that the wages which would have been paid to an [illegible] on the compressor should be divided between the two members of the union who were employed. Also it was directed that upon any day on which the cable drum was operated an additional two hours' pay should be allowed one of these men. No service was rendered by these men in connection with the operation of either machine but each man received 12 hours' pay for 8 hours' work, and if the second machine was operated, one man was allowed 14 hours' pay for his 8 hours' work.

On one occasion the engineer employed to operate the concrete mixer wished to attend a meeting of his union on an evening when it was desired to run his machine. He arranged with the foreman of the concrete gang to look after his work in his absence. The mixer was operated until 9 p. m. and the following day this engineer claimed and subsequently received double time pay for the period during which the machane was operated while he was absent.

On another job two pile driver engines were employed, each operated by a union engineer. Two small electrically driven concrete mixers were in use at the same time and the only labor required to be done upon them was that of throwing in the switch to admit the electric current. This work was done by the concrete foreman. The union required that each engineer on the pile drivers be paid two hours extra each day, although neither engineer ever tended the apparatus in question.

Unnecessary Carpenters and Ironworkers.—The Carpenters' Union requires that all temporary work, such as erecting working stagings and the like, shall be done by union carpenters; also that the stripping of forms from concrete surfaces must be done by carpenters, although it has until very recently been done in a perfectly satisfactory manner by laborers.

All men employed on or around pile drivers and lighters which are engaged upon wharf building, except the engineers, must be union wharf builders, a branch of the Carpenters' Union. Many of these men do purely laboring work, but because of their rating draw skilled men's pay.

For several years after reinforced concrete work was introduced into this locality, the steel reinforcing bars used to strengthen the concrete were handled and placed by common labor. Later it was provided in the rules of the Iron Workers' Union that all of this work should be done by members of that organization. A recent job in this locality was done by a non-union contractor using laborers to handle and place the reinforcing steel at a cost of $7 per ton. A similar union job going on at the same time required union iron workers for this purpose at a cost of $37 per ton.

Union iron workers must also be used to do any work in the nature of rigging, that is, the erecting, dismantling or operating of derricks (other than operating the engine); loading or unloading of machinery; erecting, moving or dismantling towers, chutes, etc. At the Army Base job there were used a large number of very light derricks hoisting small buckets out of the foundation excavations. The men actually used for signaling the engineer when to start and to stop were recruited from various walks in life, some being former street sweepers, some retired bartenders, others having served as janitors, but all at that time rated under a union permit card as skilled union iron workers.

Stoves used at night for the drying out of plastering may not be looked after by the ordinary watchman but must be attended by a member of the Plasterers' Tenders' Union. Similarly, all dirt or debris made by a plasterer must be cleaned up by a union tender and not by unskilled labor.

Union plumbers must be used to lay even temporary piping used for construction purposes only, as well as the suction and discharge piping of pumps

Union sprinkler fitters must be employed to lay underground cast iron pipes which conduct water to the sprinkler system; and union plumbers similarly must lay cast iron water pipes connecting with the building plumbing. Neither of these trades is as efficient as a trained laboring gang ex[illegible] of work

It must be apparent that the sole object of rules such as these is to provide work for the maximum number of members of the union in question, regardless of the economic effect upon the cost of the work.

Interference with Business.—There are numerous rules of a purely dictatorial character which serve to restrict the employer in the exercise of his natural functions.

As an illustration, the plumbers' rules provide that the employing plumber, or one of them if it is a firm, may do socalled jobbing work in the shop provided he does not do more than 50 per cent of all the jobbing to be done.

The Plasterers' Union rules provide as follows:

"The employer shall be allowed the privilege of closing his weekly payroll on Thursday night in the Greater Boston district."

A revised constitution of the Lathers' International Union adopted at the annual convention at Toledo in September of last year provides that "All locals shall have power to regulate the granting of permits to contracting lathers, provided:

"First, That the fee charged contractor or solicitor, shall be left to the discretion of each local, but not to exceed $100 and the resident limit cannot exceed one year."

The effect of this rule is actually to prohibit any contracting lather from doing business unless he first secures a permit from the union at not exceeding the sum of $100, which permit must be renewed yearly.

The Lathers' Union also contains a provision that men working less than four hours shall be entitled to at least four hours' pay and if more than four hours is worked the men must be paid at least eight hours' pay.

The Painters' Union requires that men shall not go to the shop for tools or material during the noon hour but may only do so during the working time. Similarly, the Lathers' Union provides that men shall not be shifted from one job to another during the noon hour.

Both Lathers' and Plasterers' Unions insist that when employers have occasion to do work within the jurisdiction of another local, 50 per cent of the men must be hired from that local.

The Lathers' Union specifies the particular kind of nails and staples which the employer must furnish.

Pay for Reporting.—The Hoisting Engineers' Union directs that men who report for duty shall be paid two hours' pay for reporting if not put to work, unless they have been notified at the end of the previous shift not to report. Thus, if it happens to be stormy in the morning so that no work can be done, the engineers must still be paid $2 for reporting. If an engineer is put to work at all on the day shift, he is entitled to at least four hours' pay and eight hours' pay if he starts to work on a night shift.

The engineer must be paid one hour's pay for getting up steam, which work he shall do unless the night watchman is also a licensed man, in which case the latter may get up steam for the engineer.

Work Paid for Twice.—If any work is done on or with an engine during the absence of the regular engineer he must be paid just as if he had been present. In one case an engineer was requested by his employer to work on Saturday afternoon and Sunday in order to make some needed repairs on his engine so that the work would not be tied up on the following Monday. The engineer refused because of another engagement. Thereupon the employer hired some machinists from a nearby shop who made the desired repairs. The engineer subsequently made a claim for and received pay at double time rates for the period during which the machinists worked.

Some steel reinforcement was placed by union iron workers on a Saturday. On the following Sunday a gang of laborers was used to place concrete around the rods. The steel was found to be not in its correct position and so was taken out and replaced by the laborers. The iron workers subsequently demanded and received pay for the work as if they had been present.

A hoisting engineer can be used to operate only a particular machine. Even though his engine be temporarily idle he cannot be shifted to another, but a second man must be employed for this purpose. On one job some repairs were to be made upon a large grab bucket. Machinists were brought out on a Sunday to do the work. An occasional lift by means of a derrick was required for a few minutes at a time. An engineer who was on duty looking after a pump was competent to do the necessary work, but he could not be used because the rules required that the regular engineer on the derrick was the only man who could touch the machine at any time. As a result, the regular man was used and paid at double time rate to make about six or eight lifts, while the other engineer was an interested spectator. Incidentally, it costs an engineer a $5 fine if he is caught breaking this rule.

A hoisting engineer not only must confine himself to his own machine but he must not furnish steam to a second unit unless he received two hours' extra pay per day for so doing. Furthermore, not more than one extra machine can be attached to his boiler.

No engineer is permitted to take the place of a discharged engineer without first securing the permission of the business agent of the union.

The hoisting engineers' rules provide:

In case of any misunderstanding between engineer and employer in regard to wages or conditions, engineers shall refer matter to Business Agent, whose decision shall be binding till next meeting of this union.

Restrictions on Employers.—Practically all of the unions have adopted a rule that members must be paid off during working hours and are entitled to pay at overtime rates for all time while waiting for pay after hours.

The Cement Finishers' Union insists that the employer cannot hire his men direct but only through the union office. In this manner the men are kept under strict discipline, because they may be easily penalized by the business agent for any infraction of the rules or understandings by not being assigned to a job for a week or two. It is also possible to punish a contractor when deemed desirable by sending him the poorest men or by limiting the number of men he may use.

A contractor cannot choose which engineer he desires to keep when one or more machines are shut down. He must release the man whose engine is dispensed with even though this be his best man.

More Limitation of Duties.—Engineers are not allowed to operate the water valve on a concrete machine, although the valve is purposely placed within easy reach of the operator of the machine. As a result the engineer must step aside each time the mixer is charged in order to allow a laborer to take his place for a few seconds and turn the water valve.

The Electricians' Union rules require that members working in the harbor shall be paid from time of leaving to return and in no case for less than a full day.

The minimum period for which an electrician may be paid is one-half day.

The 1921 demand of the Engineers' Union provides respecting overtime, that "an engineer shall receive not less than two hours' pay for any fraction of an hour's work."

The Stone Cutters' Union, in order to penalize any work done outside of its jurisdiction, provides that its rate of pay shall be five cents an hour more than the normal rate for work done on stone which has been partially worked elsewhere.

A certain wood carver paid his men the union rate and in addition gave them a bonus for all work over a definite amount. The union agent upon discovering this fact ordered the practice stopped upon the grounds that it served as too much of a spur to the men.

All rules, such as the preceding, are the natural consequence of the absolute power vested in the unions by reason of their monopoly of control over the industry.

Jurisdictional Disputes.—One of the annoying and expensive features of trades unionism in the building industry is that pertaining to jurisdictional disputes. There are some twenty-seven separate trades unions which have to do with building work. Frequent questions arise between them as to which one is entitled to do certain work.

For instance, carpenters and iron workers quarrel over the question of which has the right to set steel sash and door frames.

The iron workers and steam fitters both claim the right to install pipe railings.

Electricians and elevator constructors disagree over the placing of certain devices in connection with electric controls.

Iron workers and metal lathers both claim the work of placing steel reinforcing.

Cement finishers and bricklayers each insist upon pointing around steel sash.

Stone cutters and cement finishers each claim the rubbing down of concrete surfaces.

During the construction of the Army Base a number of pumps known as pulsometers were used in connection with the foundation work. They required frequent relocating and each time they were moved it necessitated the use of two stamfitters to disconnect and reconnect the steam pipes; two plumbers to remove and replace the suction and discharge pipes; then iron workers (riggers) to hoist and lower the apparatus in the holes and an engineer to turn the steam valve. The engineer and a good laborer could have done all of the work required in much less time and in an equally satisfactory manner.

Electricians and the X-Ray Machine.—A certain hospital in this city had occasion to move its X-Ray machine to a new building. A specialist, who for twenty years had done nothing but erect such machines, was engaged to do the work. It so happened that a number of union electricians were employed at the time on the new building and they immediately demanded that the specialist cease work upon the X-Ray machine and that the work be turned over to them to do.

The specialist was thereupon discharged and the union men were directed to proceed with the installation. None of the union men was experienced with such work and from time to time they called upon the operator, a female nurse, to explain to them how the machine was assembled. Repeatedly work which was found to be wrong had to be undone and changed. Finally, being utterly unable to make the machine work, the union men called upon the specialist to advise them and he refused, whereupon the union men gave up the job, the specialist was again called in and the installation finally completed.

The usual period required by the specialist for such an installation was from three to four days. Altogether, between two and three weeks were required in this case.

In addition to the excessive cost involved, all patients requiring X-Ray treatment had to be sent to another hospital during this period.

The Eight Hour Day.—Regardless of its merits or objections, the eight-hour work-day has, by more or less common consent, come to be recognized as definitely established. Such a limitation has seemed especially desirable in the case of indoor employment involving, as is frequently the case, poor light, bad ventilation and extremely close application.

The work of the building trades laborer is conducted, usually, in the open air under exceptionally good hygienic conditions, and it might reasonably be presumed that the length of the working period was a matter of less importance in this instance than in the former case.

Furthermore, the work of the building mechanic is not continuous, as is that of the factory worker, but is frequently interrupted by bad weather conditions and by lapses in employment, so that employees in this industry have many opportunities for rest and recuperation which are not open to the indoor worker. Nevertheless, the eight-hour work-day has been generally adopted in the building industry as an accepted and desirable limit and is universally insisted upon by all trades unions.

There are some reasons for believing that the labor leaders have not always been consistent in their attitude toward the eight-hour day; but however this may be, it has frequently been apparent that the workmen themselves have preferred a longer work-day, especially if it involved bonus pay in the form of overtime allowances.

Overtime Abuses.—During the war, because of the demand for excessive production, overtime work was general and accounted in large measure for the great increase of income enjoyed by labor during that period. After the signing of the armistice, however, the eight-hour day was re-established with the result that labor became very much dissatisfied and strikes on government work were frequent in protest against what was considered to be a reduction in pay.

It is a requirement of all union rules in the building industry that work in excess of eight hours per day shall be paid for at double the standard rate. The philosophy of the labor men on this point is that more than 8 hours' continuous occupation is destructive of the physical and mental well-being of the men and that, in order to prevent unscrupulous employers from exacting an excessive day's work from their employees, a penalty must be imposed which will deter them from exceeding the 8-hour period.

The amount of penalty for overtime work would be a matter of small concern to the employer were it not for the fact that it is practically impossible to avoid overtime work entirely without involving uneconomic consequences. Oftentimes it is necessary to carry the work to a certain point before stopping for the night, and if this point is not reached at the end of the eight hour period the work must be completed under penalty rates. Sometimes a small amount of preparatory work is required to be done after hours to permit the balance of the work going forward promptly the following day. Repairs to machinery must frequently be made after hours to prevent the interruption to the work which would result if they were made within the 8-hour period. For all such work the employer must pay two hours' pay for each hour actually worked.

If it were true that the unions desired only to discourage unnecessary overtime work, the result could be accomplished quite as readily by a penalty of 50 per cent additional pay as by the 100 per cent now imposed. No employer is likely to add 50 per cent or even 10 per cent to his labor cost unless it is an absolute necessity. As a matter of fact, the 100 per cent tax is really looked upon by the labor men as affording an opportunity for increased compensation, and hence the rate is deemed by them to be of considerable importance.

During the construction of the Army Base, which work was carried on day and night, the labor delegates frequently complained that some men were unduly favored by the superintendent through receiving a disproportionate share of overtime work.

A rule of the Electricians' Union reads as follows: "When a contractor finds it necessary to work men overtime, men working on the job must have the preference."

It is the custom in cement finishing work for the men to spread and level off the mortar surfacing during the forenoon and to wait for it to set sufficiently before giving it the final trowelling later in the day. The mortar last spread is usually not ready for trowelling until late in the afternoon, so that overtime in a considerable amount is usually necessary to complete the day's work.

To meet this situation, there have been introduced certain ingredients known as accelerators, which hasten the setting of the cement and permit the final trowelling to proceed almost immediately. The local cement finishers' union has refused to use these accelerators because such use deprives its members of their overtime.

Some unions require that their men shall receive double pay for all work at night, even though they be employed on a regular night shift.

An electrician was required to watch a certain piece of electric apparatus which ran continuously on a certain construction job. He was in attendance from 5 p. m. to 5 a. m. seven nights a week and received, under the union rules, 168 hours' pay per week. His duties consisted in seeing that the apparatus was oiled occasionally and he sometimes was required to throw a switch.

During the labor shortage of the past two years, employers discovered that a plentiful supply could usually be obtained by increasing the daily working hours beyond that customary in the locality with the resultant increase of bonus on the excess over 8 hours.

If labor leaders are sincere in their expressed desire to keep all jobs within the 8-hour limit, this could best be accomplished by reducing the overtime allowance to an amount which would look less attractive to their workmen and at the same time would operate to penalize the employer sufficiently to prevent its too frequent adoption.

A Five Day Week.—The 5-day week has now been adopted by five of the trades connected with the building industry. As a matter of fact, the 5-day week means the elimination of all work on Saturday, for even though the first five days of the week, or any of them, be stormy so as to prevent any work being done, the men are still prohibited from working on Saturday except under a special permit and then only at double time rates.

As long as the balance of the building trades work on Saturday forenoon, it is more or less necessary to utilize some of the men from the 5-day trades in order to prevent interruption to the work. All such men must have the permission of their business agent and in addition must receive double time for the period worked on Saturday. Naturally, this situation creates a preferred class of workmen so far as Saturday work is concerned, and, in addition to the added cost to the employer, produces an atmosphere of dissatisfaction among the men of other trades who receive only single time for Saturday forenoon.

The cumulative result of the almost innumerable requirements of the unions as applied to the building industry in Boston today is an increased cost in construction of probably at least 25 per cent. In other words, the man who builds an $8,000 house pays $2,000 merely to satisfy the whims of the trades unions, and the sad feature of the matter is that no one benefits from this expenditure.

The Unions' Great Mistake.—On the face of things, the unions assume that they are profiting through the payment of additional wages and the employment of a greater number of their members. As an actual fact, however, this increased cost of construction drives prospective builders out of the market, with the result that the total volume of work is greatly decreased and the average yearly income of the workman is reduced.

The advocates of the present union labor policy are apparently not intelligent enough to realize that for every owner who can afford to pay $20 per thousand for laying bricks, there are five or six other owners who could afford to pay $10 and who cannot build at all at the current rate. For each owner who can afford to pay $20,000 for a dwelling house, there are probably ten who would be willing to spend $10,000 for the same purpose. An hourly rate of $1.50 as recently demanded by the unions would make it impossible for anyone to build except for the most urgent reasons, and it is altogether probable that the yearly income of the men would actually be less at this rate than would be received by them under a rate of 50 ct. per hour.

The fact is that owners absolutely cannot build today, because at present costs the possible incomes to be obtained from the completed building will not pay the investment and upkeep charges. There are only two possible remedies for this situation: to increase rents materially or to reduce building costs by a substantial amount.

There are projects running in value into millions of dollars which could and would be under way in this locality now if building costs were reduced sufficiently to meet their income possibilities. Contrary to the prevailing notions of the labor unions, these buildings will not be built at present or further increased costs, and the result must be that millions of dollars which otherwise might be distributed in labor payrolls will not go into labor's pocket.

Building materials have made substantial recessions. Lumber, steel, cement, and many other commodities have suffered very material reductions in prices. It remains for labor to awake to its responsibilities and to eliminate every unnecessary and uneconomic practice which adds to cost.

Competition vs. Monopoly.—But the labor advocate tells us that the real cause of high costs is the excessive profit charged by the contractor for his service. The answer to this argument is very simple. By the provisions of law the contractor operates in open competition with all comers. Anyone, labor men included, may enter the business at any time and secure these excessive profits for themselves if they exist. Nor is it absolutely essential that they possess any great amount of capital. I have known of many contractors who began business with practically no money, but whose credit was good because of their reputation for honesty, ability in their line, and their general knowledge of their trade. No union card is required nor is anyone's permission necessary for any person to become a contractor. Most contractors would welcome a condition under which labor would put its services upon the same basis and allow each member to derive his income in unrestricted competition with his fellows, as must the contractor.

Government statistics tell us that 75 per cent of the men who enter business in the country fail, and the building business is rated as one of the most hazardous of business callings.

Undoubtedly a majority of employers would appreciate the opportunity to combine and agree upon their prices as do the members of labor unions. This, as already stated, is forbidden them and organized labor has always been loudest in condemnation of any such suggestion. It would seem, therefore, that no valid criticism can be directed against the occasional employer who succeeds in spite of these handicaps.

Discontent.—It might quite naturally be assumed that the increased pay, shorter hours and lessened unit production which union conditions have brought about, would be greatly appreciated by the workmen so benefitted. It has been my observation, however, that this is not the case. Leaders of organized labor have diligently and continuously attempted to educate their members to the belief that they are being denied their rightful share of the profits of industry; that they are discriminated against in the application of the laws and that society in general is ungrateful and unresponsive for the superior benefits conferred upon it by labor.

As a result of this effective schooling, labor is more unhappy and more dissatisfied with its lot today than at any previous time in its history. Personal initiative and individual pride of accomplishment have been almost completely destroyed by placing all men upon an equal basis of pay and of output. In addition, there has gradually come the disagreeable realization that with increased compensation and reduced output there must necessarily also ensue higher cost for commodities and a commensurate advance in the cost of living, thereby leaving the workman no better off and frequently in a worse state than before. It cannot fairly be said that such a result from the activities of any organization is indicative of a beneficent institution.

Employer and Employee.—Organized labor has always insisted that its interests are naturally antagonistic to those of the employer and this impression has very largely prevailed in the minds of the general public. Just why this assumption has been so readily adopted it is difficult for me to understand. Unless the employer is prosperous, it must be evident that his employees cannot prosper. That which makes for an increased volume of work benefits both classes, and that which restricts the amount of work which can be undertaken similarly does injury to both. It would seem to follow that the true interests of both groups lie along parallel lines.

If membership in a trades union could be made a guarantee to the employer and public alike of superior skill, efficiency, fidelity and co-operation on the part of each of its members, no intelligent employer could afford to deal with any other body of workmen even though the rates of pay were correspondingly greater for union employees.

When an employer resists demands of the union which tend to lower efficiency and to increase costs, he is working for the union's interest quite as much as for his own, for such practices inevitably reduce the volume of work and thus penalize both.

The Living Wage Must be Produced.—It has recently become popular on the part of labor unions to demand what is referred to as a living wage. As I understand the term, it is intended to represent the amount of income which will allow the recipient at current prices to enjoy the standard of living which he has established as desirable for his comfort. At the present time this so-called living wage is variously estimated at from $2,000 to $3,000 per year.

Apparently in the establishment of these figures no consideration has been given to the gross amount of wealth which is available for distribution as income. Obviously, if nothing was produced in the world, there could be no income for anybody. The greater the total production, the greater the average income becomes. Let us see what the actual figures are.

The report of the Internal Revenue Collector's Department for the year 1918 indicates that there were 1,832,000 persons in this country whose incomes for that year were in excess of $2,000, and the total income received by this class was $11,191,000,000. Assuming five members to the average family, there would be approximately 22,000,000 families to be supported. If all of the excess incomes over $2,000 were to be confiscated and divided among the remaining families, each family would receive about $374. Furthermore, the returns indicate that there were some 18,000,000 families receiving less than $1,000. This leaves 2,168,000 families with incomes between $1,000 and $2,000. Assume that the 18,000,000 families all received as much as $1,000 and that the 2,168,000 families averaged to receive $1,500, we would then have a total income for the entire country of $32,443,000,000. Divide this figure by 22,000,000 and we find the average income to be approximately $1,500 per family per year. These figures indicate conclusively that present production would have to be doubled to permit an average income of $3,000 per family in this country.

The labor leader or sympathizer who demands an increased wage combined with a decreased production is advocating an economic paradox.

The World Situation.—During the past four or five years we have experienced in this country an era apparently of exceptional prosperity. So great has the demand for all classes of labor and commodities been that wages and business profits generally advanced to unprecedented high level. The money which we paid for this labor and for the commodities was in part the accumulated surplus wealth of the countries of the world but was principally derived from the hundreds of billions of borrowed wealth which still requires to be repaid. By far the greater proportion of this money was not paid out for commodities or labor which permanently enriched the world's resources, but rather was contributed to the waste of war or for extravagances and luxuries which were of only passing value. As a result, the world's wealth has been greatly decreased and an enormous debt accumulated. It is as if the individual had squandered his personal savings and in addition had exhausted his borrowing credit, with no resulting assets with which to discharge his debts.

This great world debt has to be paid. It can be paid only by the individuals who people the earth. Each of us in the last analysis must pay our share. Those who possess money may contribute in the form of taxes. Those who have no money will contribute either in the form of additional labor or of a reduced standard of living. But no one can possibly escape his share. For any person or any group to argue that they are permanently entitled to the same (or a better) net income as they received before the war, is to argue that they should be relieved from payment of their share of this world debt.

Organized labor has shown no disposition to recognize these economic truths or to admit its responsibility for assisting in the rehabilitation of normal conditions.

Thinking people in all walks of life are awakening to a realization that the days of luxury and easy incomes which have prevailed for the last few years are now a thing of the past, and that unless world bankruptcy and economic chaos are to follow we must buckle down as never before to produce cheaply by eliminating all waste in industry and to avoid all unnecessary extravagances in living until such time as our enormous debts have been discharged. By this means only can normal conditions again be established.

If organized labor refuses to co-operate with the balance of society in bringing these conditions about, then we must go along without it.

Construction Operations in May

Construction activity in May, according to figures published by the F. W. Dodge Co., was 9½ per cent greater than in April. Contracts awarded in the 27 Northeastern States of the country during May amounted to $242,093,000, compared with $220,886,000 in April.

The increase in activity should have been greater except for widespread labor troubles. In New England and throughout the Middle West, where wage disputes have been pretty general, building activity kept up during May at about the same rate as in April. Substantial increases in activity were reported in the territory along the Atlantic Coast from New York to South Carolina.

Residential building continues to lead all other classes. In May contracts for this class of construction amounted to $82,982,000, or 34 per cent of the total. Public works and utilities amounted to $64,999,000, or 27 per cent of the total; business buildings, $29,494,000, or 12 per cent of the total; educational buildings, $24,462,000, or 10 per cent of the total; industrial buildings, $20,404,000, or 8 per cent of the total.

Building activity of the first five months of the year compares very favorably with the same period of previous years. The total investment represented by building contracts let from Jan. 1 to June 1 has amounted to $839,357,000. At the end of January, activity from the first of the year to date was 6 per cent behind the average for the preceding five years; at the end of February, 11 per cent behind; at the end of March, 4 per cent behind; at the end of April, 5 per cent ahead; at the end of May, 11 per cent ahead.

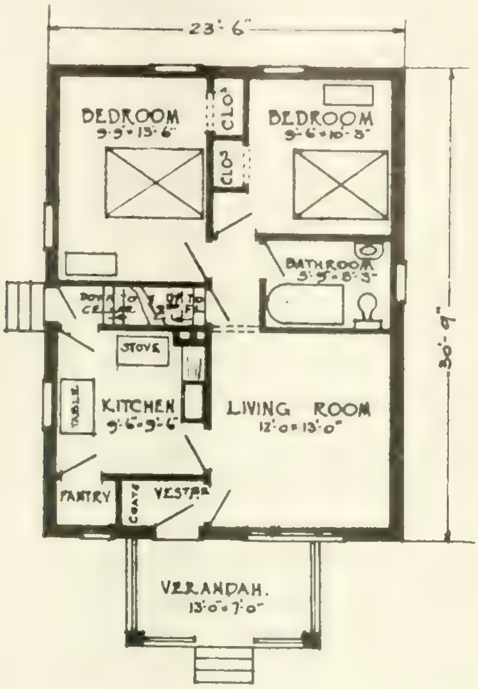
The demand for new construction still continues strong. Contemplated new work was reported in May to the amount of $462,785,000, which is 18 per cent greater than the amount reported in April.

During the first five months of the year more than two billion dollars in contemplated new work has been reported. This is considerably more than double the amount of contracts awarded, and indicates the pressure of the demand for construction. It is to be hoped that the labor disputes now in evidence will be rapidly settled so that the summer months may witness a substantial increase in activity.

House Erection on Quantity Production Basis

To overcome a housing shortage in Walkerville, Ontario, which materially affected the efficiency of factory production, and in order to place within the reach of the employes an opportunity to secure desirable homes which could be purchased by payment of a small amount down with fixed monthly payments afterwards, which monthly payments would be less than the current rents charged, the principal industries of Walkerville formed the Border Housing Co. This company undertook the erection of 100 houses in the town of Walkerville and secured the maximum amount of money allowable under the Housing Act of 1920. The balance of the money required was furnished by the company.

It was desirable, for the sake of economy, to standardize the houses as far as practicable and still do away with the monotonous and undesirable appearance of group construction so common to projects of this kind where the same architectural features of exterior construction are used throughout.



Floor Plan of Border Housing Co.'s Houses at Walkerville, Ont.

The plans finally decided upon called for a story and a half house 26 ft. 6 in. by 30 ft. 9 in. with full basement and mass concrete foundation walls to ground elevation, integrally waterproofed. From grade to first floor and in some instances to first floor windows the exterior walls are either of brick or hollow concrete blocks, four different finishes to the concrete blocks being used, viz., rock faced cement, smooth cement, rock faced granite and smooth faced granite. The foundations in all cases have a watertable course at grade. From foundation to roof-plates, all walls are of solid construction, either brick or stucco on hollow terra cotta tile. The gables, where these occur, are studded, sheeted with 1 in. matched lumber, lathed and stuccoed in all cases. All roofs, excepting dormer roofs, are shingled with cedar shingles, 14-lb. asbestos paper being used under the shingles. The dormers are covered with three-ply prepared roofing.

The interiors are as shown by the plan, the same layout being common to the 100 houses, which are plastered throughout and finished in clear fir. Ten different color schemes were used for interior painting and staining. Single pine floors were used for the ground floor and a rough floor only in the attic. The stair shown on the plan leads to an unfinished attic which has two and in some cases three windows. It is the intention of the company to let the purchaser convert the attic into one or two rooms if he so desires.

Ten different types of exterior elevations were used (10 of each type) and to further do away with too much uniformity even in each type seven different kinds of face brick were used, four different kinds of stucco, and 15 different color schemes for exterior woodwork. By using different face brick, stucco, and color schemes and varying the appearance of the foundations as before mentioned, the 10 houses in each type were each subjected to a different architectural treatment and helped to impart to each house a certain individuality not possible, without making the cost prohibitive, if any other method had been used.

The contract was awarded to the Russell-Navin Construction Co. of Toronto, Ont.

The work was well organized and the whole 100 houses completed, with the exception of a little painting and grading which could not be done until the frost was out of the ground, in 150 working days of 8 hours each, or at the rate of one house every 12 working hours. No overtime whatever was put in by the field mechanics and very little by the millmen and unskilled workmen.

The above notes and sketch are taken from the Contract Record of April 27.

Test for Organic Impurities in Sand for Concrete

An approximate test for the presence of injurious organic compounds in natural sands, intended for use in cement mortar or concrete, was given by the Committee on Concrete and Concrete Aggregates of the American Society for Testing Materials, in its report submitted at the 24th annual meeting of the society, Asbury Park, N. J., June 21-24, 1921.

The principal value of the test is to furnish a warning that further tests of the sand are necessary before they be used in concrete. Sands which produce a color in the sodium hydroxide solution darker than the standard color should be subjected to strength tests in mortar or concrete before use. The test, which was submitted as a "proposed tentative method." follows:

(a) A representative test sample of sand of about 1 lb. shall be obtained by quartering or by the use of a sampler.

(b) A 12-oz. graduated glass prescription bottle shall be filled to the 4½-oz. mark with the sand to be tested.

(c) A 3 per cent solution of sodium hydroxide (NaOH) in water shall be added until the volume of sand and liquid after shaking gives a total volume of 7 liquid ounces.

(d) The bottle shall be stoppered and shaken thoroughly and then allowed to stand for 24 hours.

(e) A standard color solution shall be prepared by adding 2.5 cc. of a 2 per cent solution of tannic acid in 10 per cent alcohol to 22.5 cc. of a 3 per cent sodium hydroxide solution. This shall be placed in a 12-oz. prescription bottle, stoppered and allowed to stand for 24 hours, then 25 cc. of water added.

(f) The color of the clear liquid above the sand shall be compared with the standard color solution prepared as in Paragraph (e).

3. Solutions darker in color than the standard color have a "color value" higher than 250 parts per million in terms of tannic acid.

Standardization of Building Materials to Lower Cost of Construction.—Creation of a permanent division of construction and housing in the U. S. Bureau of Standards is now before the Senate. Possibilites of the proposed work of the division are described in a statement prepared in the department of commerce as follows:

> Standardization of structural units and material has already been undertaken in England, but is in its infancy in this country. Standardization does not contemplate the greater uniformity in the exterior or in the interior arrangement of buildings, but rather the adoption of uniform methods and the elimination of useless types and sizes of parts, the adoption of interchangeability of parts, as well as the adoption of clear and uniform definitions of terminology. Standardization should be considered as an aim or disposition of the industries to co-ordinate their work rather than as a definition of perfection.
>
> It is urged that economy in material may be effected at an early date through the revision of building codes of many municipalities, and that such a revision toward uniformity may be brought about without impairing the usefulness, safety or durability of the structures. Flagrant variations now existing as to thicknesses of walls, floor loads, allowable stresses on timber, concrete and steel, if eliminated, might save, according to some authorities, from 5 to 20 per cent in the use of some of the materials, and might save, according to other authorities, from 5 to 20 per cent in the total cost of certain types of construction.
>
> The subject of economy in methods of manufacturing and distribution involves not only more scientific plan operation but also more continuous operation. Identification of the causes of the irregularity and intermittency of operation particularly inherent in the construction industry may bring about, it is hoped, elimination of some of these causes and the elimination of loss through the frequent plant idleness and unemployment.

Conservation of Corrosion Weakened Steel Stacks by Encasing With Concrete

By JOHN V. SCHAEFER.
President, Cement Gun Construction Co., Chicago.

Rather than tear down a steel stack, which was in condition requiring renewal, causing shut down of the pumping station at South Works of the Illinois Steel Co., at South Chicago, in 1919, it was decided to use the cement-gun in reconstructing the stack. By coating the outside with reinforced cement-gun concrete, a new self supporting stack has been built upon the existing foundation.

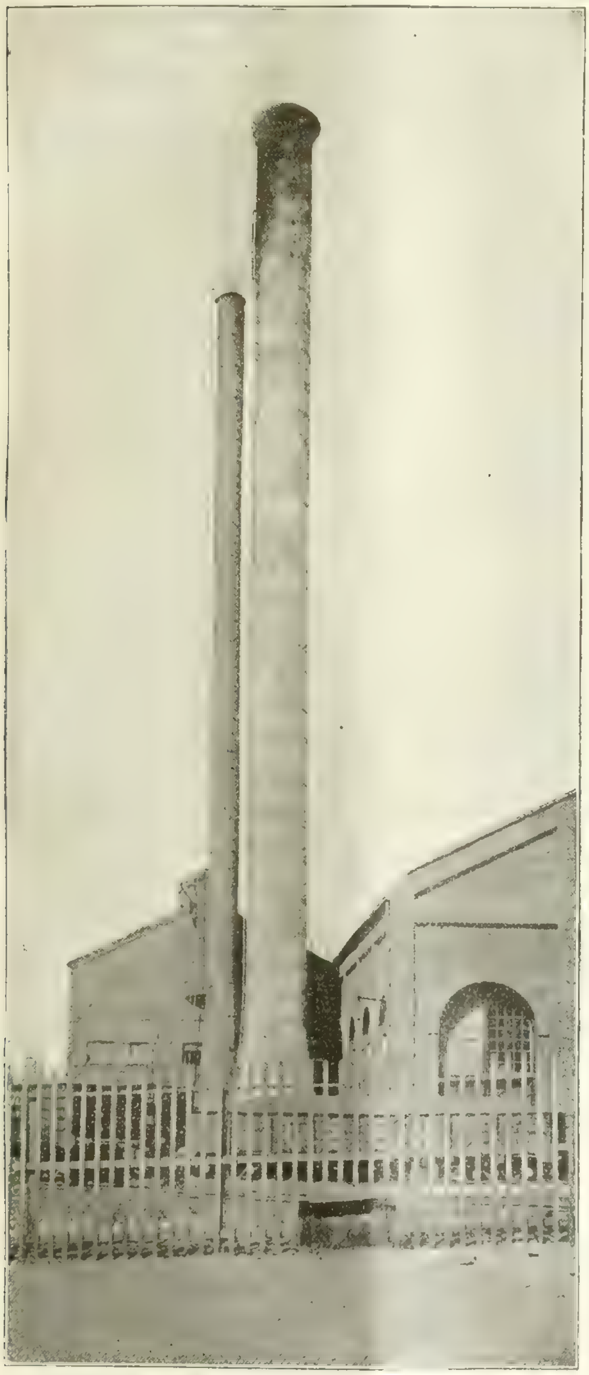


Fig. 1.—Concrete Encased Stack at South Works, Illinois Steel Co.

This steel stack was 175 ft. high by 9 ft. diameter. A reinforcing network of sufficient strength to make the new stack self-supporting without any help from the existing stack was built up of rods and wire mesh and secured to the existing foundation bolts. A cement-gun was then used to shoot "Guncrete" or Gunite, as it is variously called, through the reinforcing mesh against the existing steel shell to the required thickness. A mixture of sand and cement hydrated in the nozzle was applied with an air pressure of about 35 lb. The guncrete is 18 in. thick at the base, tapered rapidly to 6 in. just above the bell base and then gradually decreased to 4 in. at the top.

The cement-gun remained on the ground. The dry mixture of sand and cement was blown through the hose by air from a compressor working at about 50 lb. pressure. Water was forced through the water hose, at a pressure great enough to give a pressure at the nozzle in excess of the air

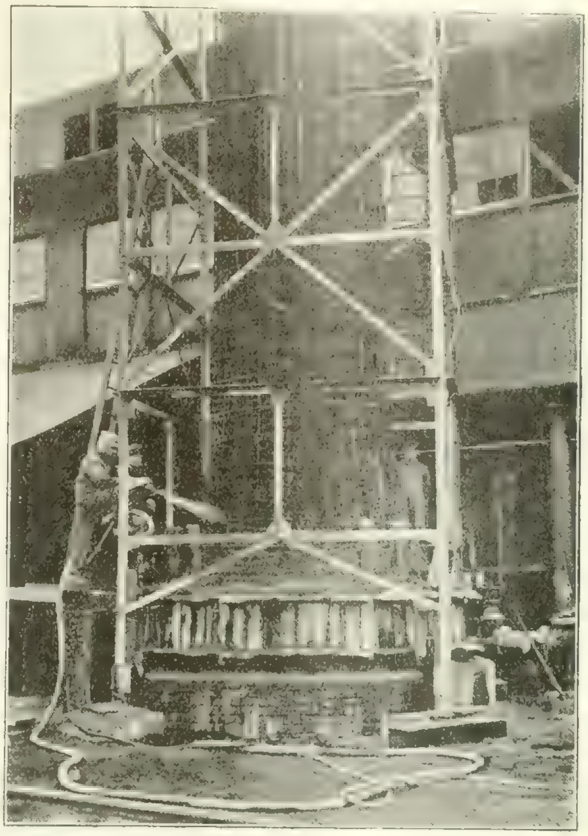


Fig. 2.—Reinforcement in Place and "Shooting" Just Begun on Stack at Lorain, O.

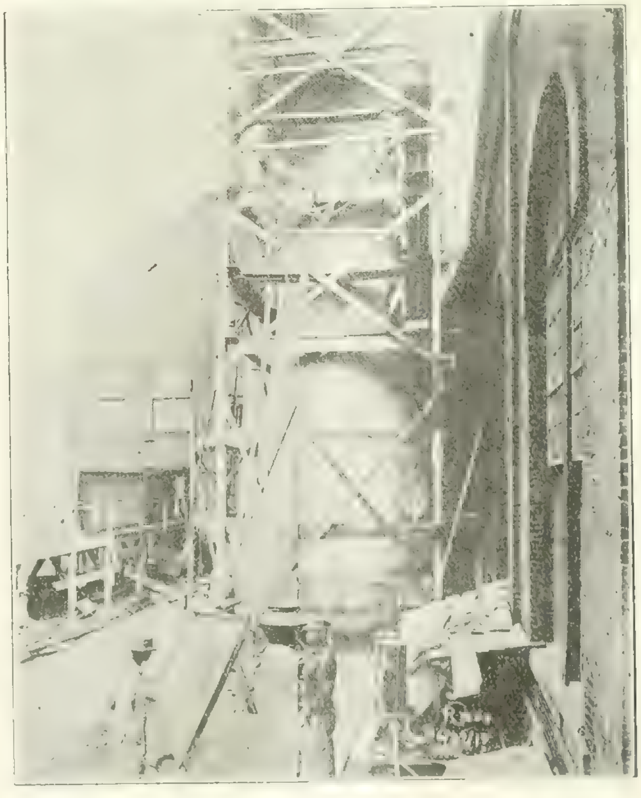


Fig. 3.—Cement Gun Work on Stack of Illinois Steel Co.

[illegible] The operator worked upward from the bottom, finishing as he went, so that at the end he was 175 ft. above the ground and material was forced [illegible] to the nozzle at that point.

All the work was done without interrupting the use of the stack. The guncrete was applied while the steel was too hot to permit holding the hand against it. The breeching extending from the side of the boiler house to the stack was also encased with 3 in. of guncrete while it was so hot that water thrown against it boiled. The guncrete was kept thoroughly sprinkled until set. The effect of the hot stack seemed to be that of steam curing and after being in use for nearly 3 years the guncrete is everywhere sound and shows no cracks.

Figure 1 shows this stack as it appeared when completed. So successful was the work that others have taken advantage of this method of saving stacks that were otherwise serviceable. A list of such stacks, for which data have been available to the writer, is given below; doubtless there are others:

		—Size—			
No	No. of stacks.	Diam. In.	Height Ft.	Year.	Remarks.
1	1	115	175	1918	These were at a pumping plant which could not be shut down. Work was done without interrupting service. Work was done in July during very hot weather.
2	5	90	125	1918	Two of these were out of commission when encased and hence cold. The other three were in regular service and hence at normal temperature.
3	2	68	110	1918	These were done in December with weather so cold that work had to be protected against freezing. Both stacks were in regular service.
4	2	60	100	1920	Work done in July. One was in service, the other out of commission. This was a repeat order from same people who have No. 1. These stacks sometimes have temperatures running up to 1200°.
5	3	68	110	1920	Repeat order same as No. 3. Work done in December. Weather cold. Work had to be protected against freezing. One stack cold, the otner two in service.
6	6	90	150	1921	These are now under construction, four being finished. The first one was done in January. Weather was cold. Stack was out of commission. Sufficient fire was made in stack to bring steel plate above freezing point and work was protected against freezing. The other three were in commission and the remaining two will be done while in commission.

The above list comprises 19 stacks including two not yet finished. Seventeen of these are in daily use. Eight of them have gone through two winters. None of them show any cracks, except a few surface craze cracks, which do not penetrate perhaps more than ⅛ in. Some were encased while cold, some while hot, and all of them are in daily service and are perfectly sound.

Figure 2 shows one of the two stacks noted in the table No. 3. This shows reinforcement in place and shooting just begun. Figure 3 shows stack of Illinois Steel Co. with cement gun work completed to a height of about 25 ft. The large hose shown in the illustration carries the material and the small hose conveys the water.

Strength of Metals and Alloys.—Useful information on the strength and related properties of metals and alloys is given in Circular No. 101 issued recently by the U. S. Bureau of Standards, Washington, D. C. The data are given on the tensile strength, proportional limit, percentage of elongation in 2 in., percentage of reduction of area, Brinell and scleroscope hardness of such materials as iron, carbon steel, alloy steels, wire and wire rope, semi-steel, aluminum, copper, etc. In addition, figures are given in some cases for the compressive and shearing strengths and moduli of rupture.

Suburban Development of Roman Seashore.—A new electric rapid transit line between Rome and Anzio, where Nero had his seashore palace, is to be put into operation soon. The journey is expected to take but forty-five minutes, while trains will be run every half hour. The project will be effected by electrifying the present state railroad which runs to Anzio, and it is expected that many Romans will now live [illegible] and "commute" to business in American fashion.

Plastic Gypsum

Plastic gypsum is the name given to a new product, more plastic and hence more economical than ordinary gypsum. It is described in an article by Mr. W. E. Emley in a recent issue of Chemical and Metallurgical Engineering, from which we have taken the matter as follows:

Wall plaster is composed of three coats, known as "scratch," "brown" and "finish." The scratch coat is next to the lath, the brown coat in the middle, and the finish coat is applied to the exposed surface to give the plaster a pleasing appearance.

The quality requirements put upon material for the finish coat are peculiar: It must be very plastic in order that it can be spread in a thin layer (1/16 in.) over the brown coat, which has set and is partially dry; and it must set in 20 or 30 minutes, in order that the plasterer may finish troweling it without moving his scaffold.

The scratch and brown coats may be made with either plaster of paris and sand or of lime and sand, but the finish coat must consist of both lime and gypsum plaster. The addition of lime is necessary to give the proper degree of plasticity. As the weight of the finish coat is very small in comparison with the weights of the two other coats, the contractor must provide enough for all three coats and a small amount of lime for the finish coat mixture when gypsum plaster is used. It seems impossible to get good results with a ready mixed lime gypsum plaster. The lime must be soaked with water for at least 24 hours in order to develop its plasticity, and the gypsum cannot be soaked, because it sets upon the absorption of 1½ mols of water of crystallization. This means that the materials must be prepared separately and mixed just before being used, thereby requiring extra labor and equipment.

The higher plasticity of lime makes it more economical in material and labor. Lime can carry three parts sand for scratch and brown coats, while gypsum plaster carries only two. If lime and gypsum are sold at about the same price, lime plaster will be cheaper than gypsum. Also the labor of applying the plaster is reduced in the case of lime.

If a form of gypsum plaster could be prepared as plastic as hydrated lime it would not be necessary for the gypsum manufacturer to add lime or any other foreign material (except retarder) in the preparation of neat gypsum plaster. These results are greatly to be desired, not only by the gypsum industry, but also by the general public, because they would tend to decrease the cost of an important building material.

Accordingly, work was started on an attempt to make gypsum plaster as plastic as lime. The first successful experiment was completed on Sept. 13, 1920, and since that date sufficient work has been done to make sure of the practicability of the method. The problem may therefore be considered solved, in so far as it can be solved with laboratory equipment.

At first fine grinding was tried to increase the plasticity. Fine grinding in itself is not new in the industry, and it would seem strange that any increase of plasticity due to it could have passed unobserved. Investigation has shown, however, that all attempts at fine grinding on a practical scale had been conducted in a buhr or tube mill. It has long been known that the half mol of water of crystallization can be "ground out" of gypsum plaster. When it is reduced in either of the above types of mills, the volume of air passing through the mill carries off the water vapor as fast as it is formed by the frictional heat. If the grinding is sufficient to liberate all of the water, the resultant product is soluble anhydrite. This is a peculiar form of anhydrous calcium sulphate and differs from the mineral anhydrite in its great affinity for water. So great is this affinity that a very short exposure to moist air is sufficient to change it back to the hemihydrate. When ground in the usual type of equipment and the frictional heat is not sufficient to liberate the water of crystallization, the size of the grains is not greatly reduced. If the anhydrite is formed, the final product soon absorbs water from the air and the crystals cake into larger aggregates that do not give a plastic plaster.

A new product results from the grinding of calcined gypsum under circumstances not permitting the escape of water. The product then is plastic and the degree of plasticity depends to a certain limit upon the duration and speed of grinding.

The plasticimeter described in Bureau of Standards Technologic Paper 169 is not yet adapted to measure the plasticity of unretarded calcined gypsum; the material begins to set before the experiment can be completed. Use has therefore been made of the Carson blotter test, as described in the **Transactions** of the National Lime Manufacturers' Association for 1916. This has proved quite satisfactory as a means of differentiating between the plasticities of finishing hydrate and masons' hydrate. When tested by this method, this "plastic gypsum" proves to be more plastic than the best lime putty.

Besides improving the plasticity, the process also causes certain changes in other properties of the material. The increased fineness of the plastic gypsum naturally necessitates the use of more water to bring the paste to a given consistency. Yet, in spite of this excess water, the set material will average about 20 per cent stronger than that made from ordinary calcined gypsum. The process slows down the setting reaction somewhat. The time of set of one sample was changed from twelve to seventeen minutes by this kind of fine grinding. Commercial calcined gypsum usually deteriorates somewhat on storing. It tends to work "lean" and carry less sand. Samples of this plastic gypsum have been exposed to the air for four months without apparent deterioration of their plasticity.

The process has been applied with equal success to calcined gypsums from Nova Scotia, New York and Virginia. It would seem, therefore, that the original quality of the material is of little importance.

The material was ground in a Call mill, so constructed that the water vapor cannot escape.

Commercial calcined gypsum is always ground during the course of manufacture, either before or after calcination, so that the grinding required to make plastic gypsum does not entail the installation of an extra process. It would seem, however, that the grinding should be done after calcination rather than before to prevent the powder balling up in the mill.

It is probably not essential that a ball mill be used; a buhr mill or tube mill may be satisfactory if there is no loss of water by evaporation during the grinding. It is essential that the product as it leaves the mill shall contain approximately the same quantity of fixed water as commercial calcined gypsum does: about 6.2 per cent water.

The duration of grinding required to make plastic gypsum depends upon the kind of equipment used, the fineness and hardness of the material, and the degree of plasticity desired. This problem must be worked out individually by each manufacturer for his particular equipment and material. It is a simple matter to regulate the grinding until the Carson blotter test shows the material to have the desired degree of plasticity. Laboratory experiments indicate that the output will be considerably reduced, perhaps cut in half, if the same equipment is used to make plastic gypsum.

The new product, "plastic gypsum," was demonstrated at the annual meeting of the Gypsum Industries Association on Dec. 15, 1920, but the process of manufacture was not divulged. A patent, covering both the process and the product, has been applied for, and, if granted, will be given to the public for the free use of anyone in the United States. This description of the process is being released at this time in order to give additional protection to the public interest.

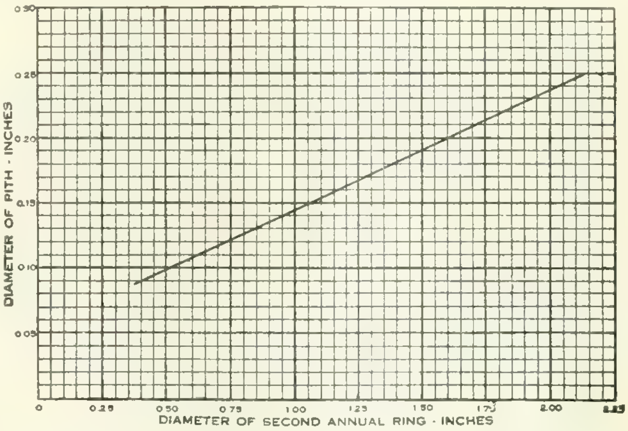
Lumber Production in 1909 and 1919.—A preliminary comparative report on the production of lumber by species for 1919 and 1909, has been issued by the Bureau of the Census. The data shown for the two years are comparable and include the cut of merchant and custom sawmills for both years. The total number of mills reporting in 1919 was 30,235 as compared with 46,584 in 1909:

Kind of wood.	1919 quantity (M ft. BM)	Per cent distribution	1909 quantity (M ft. BM).	Per cent distribution
Yellow pine	13,062,900	37.8	16,277,200	36.6
Douglas fir	5,902,200	17.1	4,856,100	10.9
Oak	2,708,300	7.8	4,411,500	9.9
Western yellow pine	1,755,000	5.1	1,500,000	3.4
Hemlock	1,755,000	5.1	3,051,100	6.9
White pine	1,723,700	5.0	3,900,000	8.8
Spruce	980,000	2.8	1,748,600	3.9
Maple	857,500	2.5	1,106,600	2.5
Red Gum	851,400	2.5	706,900	2.1
Cypress	656,200	1.9	955,600	2.1
Chestnut	545,700	1.6	663,900	1.5
All other species	3,751,200	10.8	5,328,700	11.9
Total	34,552,100	100.0	44,509,800	100.0

A Visual Method of Distinguishing Longleaf from Shortleaf and Loblolly Pine

In the examination of specimens of wood from the southern pines at the U. S. Forest Products Laboratory, a distinct difference was noted in the size of the pith of longleaf pine and that of shortleaf and loblolly pine. This difference suggested an easy method of distinguishing the pines, which would be particularly useful to the lumberman because it did not require a microscope. Obviously, this method can be used only on ties and timbers cut from the center of the tree; but it is, as a rule, only regarding large pieces that the lumberman or contractor desires to know the exact species.

The pith, or small, dark, soft core at the center of the tree, averages larger in longleaf than in shortleaf or loblolly pine. In longleaf the pith is over 0.1 in. in diameter; in the other two species it is smaller, usually about the size of the lead in a pencil, except in trees of very vigorous growth, in which it may be as large as in longleaf. The vigor of a tree at the time the pith was formed is indicated by the diameter of the second annual ring. Therefore, where the pith in loblolly and shortleaf is over 0.1 in. in diameter, the diameter of the second annual ring is comparatively large; in fact, it is larger than in longleaf having the same sized pith.



Relation of Diameter of Pith to Diameter of Second Annual Ring.

How to Use the Pith and Second Annual Ring for Identification.—With a sharp knife carefully smooth the end surface of the pith and surrounding wood. If the pith or second annual ring is not clear, moisten the smoothed surface. If knots are present near the pith, satisfactory measurements can not be made, and the other end of the timber should be inspected.

If the pith is about the size of the lead in the ordinary lead pencil or smaller, the specimen is not longleaf, and no further measurement is necessary.

If the pith is plainly over 0.1 in. in diameter and the growth rings surrounding it very narrow, the specimen is longleaf.

If in doubt as to the species, carefully measure the average diameter of the pith, not including small projections, using a rule graduated in twenty fifths or fiftieths of an inch. A reading glass or other small lens is helpful but not essential in making these measurements. Then measure the diameter of the second annual ring in tenths of an inch. The first and second rings are usually very distinct, but in some pieces the first annual ring is rather faint, and care must be taken not to mistake the third annual ring for the second. Sometimes false rings are present, but these can always be recognized by the fact that they are not prominent all the way around, and their outer limit is not defined by a sharp line.

On the diagram find the point where the vertical line which indicates the diameter of the pith intersects the horizontal line which indicates the diameter of the second annual ring.

If the point of intersection falls above the diagonal line in the diagram, the specimen is longleaf, or in rare instances, slash, or pond pine. If it falls below the line, the specimen is not longleaf, but is shortleaf, loblolly, or some other of the minor southern pines.

The Need for Standardization of Building Codes

At the present time there is a great cry for more homes [illegible] homes. [illegible] to stimulate building and stimulate interest in house construction, an important and practical suggestion, not alone in its present influence but in its effect on future building, is to revise building codes and to make their requirements as nearly uniform as possible throughout the country. In almost hundreds of cities, building codes are now in operation which were prepared or approved a decade or more ago and have not been revised or amended since that time. These codes fail to take into consideration the advances made in the scientific and efficient use of structural materials and, in numerous cases, changes might be made which would reduce building costs while still retaining safe structural requirements. In a paper presented at the recent 54th annual convention of the American Institute of Architects, Mr. D. Knickerbocker Boyd brings out some interesting information regarding the thickness of wall requirements in the various building codes and their effect on cost and plans of small houses. An abstract of the paper follows:

Code Provisions for Brick Exterior Walls.—One of the most obvious of these necessary revisions, relating to wall thicknesses, was brought to light recently in an investigation by the Structural Service Bureau of some 100 building codes throughout the country. These results thus far verified are tabulated as follows:

CODE PROVISIONS FOR BRICK EXTERIOR WALLS IN DWELLINGS.

	Cities.
One story dwellings, 8 in. walls	63
One story dwellings, over 8 in. walls	14
Two story dwellings, 8 in. walls, both stories	28
Two story dwellings, over 8 in. walls, first story	31
Two story dwellings, over 8 in. walls, both stories	19
Three story dwellings, 8 in. walls, all stories	6
Three story dwellings, over 8 in. walls, first story	10
Three story dwellings, over 8 in. walls, first and second stories	21
Three story dwellings, over 8 in. walls, all stories	39

Schedules have been prepared which list the variations and give the width, area and height limit of houses in relation to each thickness of wall. The lists are prepared on a generally comparable basis as to size of house and give the requirements, according to latest available information for a 2-story house.

The same city is in some cases included on two lists, apparently contradictory. This is due to the code requiring thicker walls inside the fire limits, or special regulations covering areas or heights. An example of this is Albany, N. Y., where 8-in. walls are permitted in the second story of a 2-story dwelling, outside the fire limits, but when inside the fire limits, a 12-in. wall is required—whereas in New York City, or in Philadelphia, the 8-in. thickness is permitted in both stories within the fire limits.

The first list includes some 29 municipalities permitting 8-in. walls in each story of a small two-story house, as follows:

Baltimore, Md.; Birmingham, Ala.; Boston, Mass., Buffalo, N. Y.; Cambridge, Mass.; Cleveland, O.; Cincinnati, O.; Columbus, O.; Camden, N. J.; Dayton, O.; Detroit, Mich.; Duluth, Minn.; Hartford, Conn.; Minneapolis, Minn.; New Bedford, Mass.; New Orleans, La.; New York, N. Y.; Philadelphia, Pa.; Portland, Ore.; Pittsburgh, Pa.; Rochester, N. Y.; Seattle, Wash.; Syracuse, N. Y.; Tacoma, Wash.; Tampa, Fla.; Trenton, N. J.; Washington, D. C.; Wilmington, Del.; Worcester, Mass.

The second list includes cities requiring the walls in the first story of a small house to be 12-in. or 13-in. thick, but providing for an 8-in. or 9-in. wall in the second story. There are 31 cities on this list, as follows:

Albany, N. Y.; Albuquerque, N. M.; Boise, Ida.; Butte, Mont.; Chicago, Ill.; Dallas, Tex.; Davenport, Ia.; Denver, Colo.; Grand Rapids, Mich.; Indianapolis, Ind.; Jacksonville, Fla.; Kansas City, Kan.; Knoxville, Tenn.; Lawrence, Mass.; Los Angeles, Cal.; Manchester N. H.; Memphis Tenn.; Milwaukee, Wis.; Norfolk, Va.; Oakland, Calif.; Omaha, Nebr.; Providence R. I.; Richmond, Va.; Salt Lake City, Utah; San Francisco, Cal.; Savannah, Ga.; Spokane, Wash.; Springfield, Mass.; Toledo, O.; Worcester, Mass.

The third list includes those cities which require the walls in each story in every small house two stories in height to be 12-in. or 13-in. thick. There are 19 cities on this list, namely:

Albany, N. Y.; Atlanta, Ga.; Augusta, Ga.; Bridgeport, Conn.; Buffalo, N. Y.; Chattanooga, Tenn.; Des Moines, Iowa; Jersey City, N. J.; Louisville, Ky.; Lowell, Mass.; Nashville, Tenn.; Newark, N. J.; New Haven, Conn.; Paterson, N. J.; Petersburg, Va.; Shreveport, La.; St. Louis, Mo.; St. Paul, Minn.; Wichita, Kan.

Consulting these lists it is plain that in some cities it is possible to construct a 2-story dwelling with 8 in. walls for both stories above basement, while in a neighboring city, perhaps not 10 miles distant, 12 in. walls are required throughout. Why should the thicker wall be required if the 8 in. wall is equally safe and is approved by 28 cities, among them some of the largest in the country?

Effect of Wall Thickness on Cost.—Of especial interest to the home builder, is the fact that the use of an 8 in. wall means a saving to him in money and space. Just how much of a saving in money can be visualized by a specific example:

The following figures are based on two storied walls, not allowing for half stories, gables or for openings, and disregarding whether the foundations are of stone, concrete, brick or other solid material. In a house 20x30 ft.—using that merely as a convenient standard of size for the purpose of calculating—there will be a saving between an 8 in. wall and a 12 in. wall, of 12,500 bricks (in round numbers). Those extra bricks would mean, at the average current price, that from $250 to $300 has been added to the cost of the house for the brick alone, to which a like sum must be added for the cost of the mortar and the time of the bricklayers and helpers necessary in laying of the extra 12,500 bricks. In other words, a house of the same outside dimensions would cost from $500 to $600 more in Albany or St. Louis than it would in Pittsburgh or Seattle.

In addition to safe structural requirements and money savings there are other important features. The difference in thickness of the walls increases the area on each floor by about 30 sq. ft., or in other words, the 8 in. wall means about the size of a small bathroom or several large closets added to each story.

The coal required to produce the additional material for the thicker wall would amount to 6 tons for each house. While that means, in the cost of the coal at the place where the material is burned, we will say $50—which amount is included in the money saving before mentioned—think of the conservation of coal and transportation which an 8 in. wall effects. Six tons and its hauling eliminated with each house built! If we construct the walls in the smaller or isolated houses, hollow, with brick or hollow tiles where hollow material is permissible, there is still a further saving of about 2½ tons of coal.

The U. S. Housing Corporation adopted for its War Housing Developments, the 8 in. thickness as standard for brick walls of houses. In all localities this thickness, which was only accepted after thorough investigation was used in spite of any prevailing regulations to the contrary. That corporation and the Emergency Fleet Corporation adopted the 8 in. thickness as an amply safe and sound all-time standard for small houses, and not as a war measure of expedient.

Effect of Wall Construction on Plans.—As an instance of the effect that wall construction may have upon type of plan; —in the City of Philadelphia, 9 in. walls have long been allowed, but this thickness has been limited to a building not over 16 ft. wide. The operative builders of Philadelphia found that they could sell much more readily, a house that had more light and more air than the old conventional type—a house with an L at the back and a narrow court.

But according to the Building Laws, they had to make the better-planned wider houses with walls 13 in. thick, therefore many of them stuck to the old type of building; because being narrower it could have 9 in. walls and hence was cheaper. So the Operative Builders called on the Chief of the Bureau of Building Inspection and explained the situation; and he, thoroughly convinced that a change was desirable said: "We will prepare and submit an Enabling Act to the Legislature of Pennsylvania." And last year, among them all, they amended the 16 ft. act so that houses 20 ft. wide could be built with 8 in. walls and the type of plan for dwellings in Philadelphia is now developing into what is called the "air-light" house without any back extension and departing from the old one with a narrow court-like yard.

Wages, Living Costs and Commodity Prices

We present herewith a diagram showing the subjects of this title plotted from December, 1914, to date, as percentages of the average rates for the initial date—that is, December, 1914, is taken as 100 per cent in each case. Averages are shown for the month of December of each year, and for June in the past two years. We should have preferred data for more frequent intervals, but as the data on cost of living were available only as given, we have kept the whole in the same form.

Wholesale commodity prices represent the average weighted index prices of 326 commodities prepared by the U. S. Bureau of Labor Statistics, and printed each month in Engineering and Contracting. They are for the entire United States. The curve of cost of living is an average from data recently published by the same Bureau for 11 different cities, and the wage diagram is taken from the New York Evening Post's diagram prepared from data furnished by the New York State Department of Labor. While, as thus observed, the data pertain to somewhat different geographical districts, they nevertheless furnish a very fair criterion of relative cost movement as applied to our most populous state and to the country as a whole.

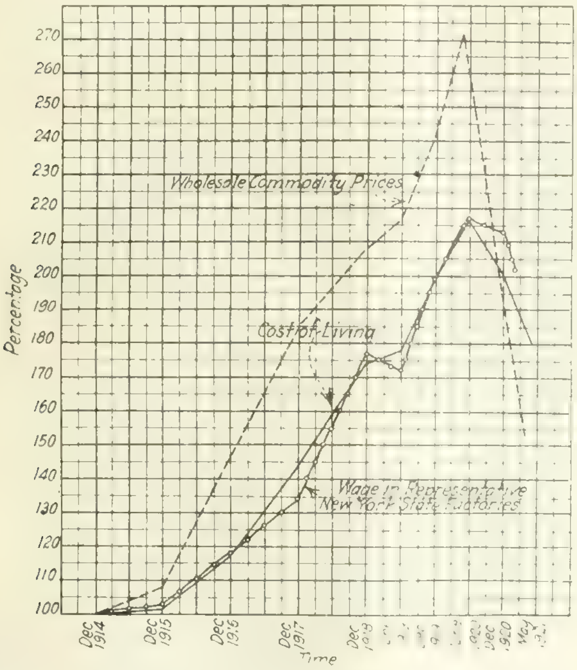


Diagram of Wages, Living Costs and Wholesale Commodity Prices.

The correspondence between wages and cost of living is most striking, and corroborates the frequent statement that the wage earner's purchasing power has not fluctuated greatly. Of course, this is as an average only, for certain trades have experienced marked changes.

It is interesting to note that while the wholesale price curve has a form substantially like the other two, and that its major variations are almost coincident in time with the others, its range of variation is much greater. This is attributable in part to the speculative element in the wholesale prices. The striking manner in which its advance outstripped both wages and the cost of living suggests but does not prove profiteering in commodities other than those classed as living costs; and its present position below the other two curves shows that some of the profits (reasonable or otherwise) are now being wiped out.

The eleven cities represented on the cost of living curve, and their respective living costs for May, 1921, in terms of 100 per cent for December, 1914, for each individually are as follows:

	Per cent
Boston	[illegible]
Portland, Me.	172.1
Buffalo	[illegible]
New York	[illegible]
Philadelphia	179.8
Savannah	[illegible]
Jacksonville	[illegible]
Mobile	[illegible]
Cleveland	[illegible]
Detroit	[illegible]
Chicago	[illegible]
Average	[illegible]

The items representing the cost of living and the average percentages of the total for these cities in 1914 are:

	Per cent.
Food	38
Clothing	17
Housing	14
Fuel and light	5
Furniture and furnishing	5
Miscellaneous	21
Total	100

Wage indexes for the period are also furnished by the Bureau of Labor Statistics. As averages they are subject to considerable uncertainty because of the rapid changes which were taking place during each of these years, but they afford the best evidence we have for the country as a whole. The Bureau's figures are as follows:

Year	Hourly wage index. Per cent.
1913	100
1914	102
1915	103
1916	111
1917	128
1918	162
1919	184*
1920	234†

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*For the spring of 1919.

†For the summer of 1920.

It is to be observed that the hourly wage index agrees quite well with the middle points for each year on the curve of wages in New York state factories.

As we go to press returns on the cost of living are received from six more cities, with percentages for May, 1921, in terms of December, 1914, as follows:

	Per cent.
Washington, D. C.	167.1
Baltimore, Md.	177.4
Houston, Texas	179.7
Seattle, Wash.	180.2
Portland, Ore.	162.2
San Francisco and Oakland, Calif.	166.7
Average of the six cities	172.2
Average of seventeen cities	177.3

Properties of White Metal Bearing Alloys at Elevated Temperatures.—The U. S. Bureau of Standards, Washington, D. C., has just issued Technologic Paper No. 188, giving the results of investigation of the mechanical properties of white metal bearing alloys. The paper contains a description of an apparatus for determining the yield point and ultimate strength of white metal bearing alloys at temperatures up to 100° C. A new design of heating apparatus for determining the Brinell hardness of metals at temperatures up to 100°C. also is described. The results of compression tests and Brinell hardness tests at temperatures up to 100° C are given for five typical white metal bearing alloys, including three tin-base alloys, one lead-base alloy, and one intermediate alloy, which show that the tin-base alloys maintain their properties better at elevated temperatures than the lead-containing alloys. Results of tests are given which indicate that up to 5 per cent of lead in a high-grade babbitt does not affect the yield point or ultimate strength at 25 or 75° C. The yield point of tin-base alloys is not affected by heating for six weeks at about 100° C, but the yield point is lowered in the lead-base alloy by heating for two weeks at about 100° C.

Training School for Civic Executives.—The Bureau of Municipal Research of New York City has been fused into a new corporation known as the National Institute of Public Administration. The bureau, which was established in 1906, has been rendering service to municipal, county, state and federal governments in all phases of public administration. In 1911 they added to the bureau a training school for civic executives, and it is this phase of the bureau's activities which the new organization will emphasize. The National Institute plans to train men and women in the practical work of public administration. Luther Gulick heads the institute as acting director, Clarence B. Smith, Jr., as manager and Raymond B. Fosdick as counsel. Men well-known in the fields of municipal finance, engineering, public health, city planning, etc., are listed as instructors, lecturers and consultants. An announcement of the courses for 1921-22 has just been issued and may be secured from their offices at 261 Broadway, New York City.

Old Masonry Arch Bridges of Paris

At the present time there [illegible] over the River Seine within the city limits of Paris. Of these bridges 20 are masonry arches and 12 are metallic arches. Until the end of the 18th century all masonry bridges in Paris were built with semicircular or almost semicircular arches; from 1787 to 1852 all had segmented arches and after that time, beginning with the new Pont Notre Dame, all had elliptical arches. An interesting account of these bridges of Paris is given by Carl L. Rimmele, formerly first lieutenant, engineers, U. S. Army, in the current issue of The Military Engineer. From his article we have abstracted the matter relating to some of the older masonry arch bridges.

The Pont Neuf.—This is the oldest bridge in Paris and the best known bridge. The first stone was laid by Henry III in May, 1578, and the work was carried on until the piers were well above the water. At that time, however, owing to the Civil Wars, operations were suspended and were not resumed until several years later, when Henry IV (Henry of Navarre) ascended the throne. The bridge was finally completed in 1604.

This bridge is 232.88 meters long and divided into two sections, one over the main branch of the Seine composed of seven masonry arches, the other separated from the first by the extreme western end of the Ile de la Site, composed of five arches.

The arches are very nearly semi-circular, built of cut stone, and are slightly skewed. The spans vary from 14 meters to 17.55 meters. The depth of the arches at the keystone is 0.75 meter. They are 20.65 meters long between faces in the northern or main branch section, and 20.35 meters long in the southern section. The deck is 20.30 meters wide between parapets, accommodating an 11.30-meter roadway and two 4.5-meter sidewalks.

The piers rest on timber platforms, which, although laid directly upon the sand, were, when the bridge was constructed, about 3 meters below the river bed. These platforms consist of 0.40 by 0.40 by 7.0-meter sleepers parallel to the center line of the bridge, spaced 1 meter center to center, covered with a floor of 16 centimeters (6-in.) oak planks.

This bridge, completed in 1604, was in constant use until the middle of the last century without any repairs having been made. In 1848, however, the bridge was found to be badly in need of repairs; in fact, many of the arch stones had become loosened and fallen out. The work started that year included the reconstruction of seven of the arches, lowering the roadway and constructing galleries for water lines. Care was taken that the original appearance of the bridge should not be altered and sculpturing which could not be restored was replaced with accurate copies, for Paris has a tender affection for the old Pont Neuf. This entire work was carried on under traffic, half the roadway being kept open at a time, and covered a period of four years.

In 1885 one of the piers settled to such an extent that longitudinal fissures over a half meter wide appeared in the roadway. Investigation showed that the upstream half of the pier had been undermined, and that, since the construction of the bridge, the bed of the river had been lowered more than 3 meters, so that in some places it was below the pier footings. The repairs, which were started immediately, included the rebuilding of half the pier and half the adjoining arches.

The new footing was built in a caisson sunk to a depth of 4 meters below the old footing. Around the rest of the pier narrow caissons, 2 meters wide, were sunk to the same level and filled with masonry, completely surrounding that half of the pier. Over the new halves of the reconstructed arches spandrel walls were used instead of the filling as in the old part.

After this work had been completed, sheet piling was driven around the other piers, as well as around the abutment footings, and capped with masonry. Cement grout was then pumped in under the old footings to partly consolidate the [illegible]

The total expenditures charged to this famous bridge during its more than 300 years of service, have been less than 3,000,000 francs.

Pont Marie.—Ten years after the completion of Pont Neuf a bridge was started connecting the north bank of the Seine with the Ile St. Louis. This bridge was designed and its construction begun by Cristophe Marie, whose name it bears, but was later taken over and completed by Delagrange, in

The Pont Marie is 92.27 meters long between abutments and consists of five nearly semi-circular arches of cut stone. The largest arch has a span of 17.65 meters, and the smallest, 13.76 meters. The width between faces is 23.60 meters. The keystone depth is 1.75 meters.

The foundations are masonry footings placed directly upon the gravel of the river bed.

In 1658 two arches were washed out and were replaced six years later. Except for this, there is no record of any expenditures during 300 years of use.

Pont Tournelle.—In 1654 the Pont Tournelle was constructed over the southern channel, opposite the Ile St. Louis, which, with the Pont Marie, completed the crossing at that point.

The bridge, as originally built, consisted of six semi-circular arches of cut stone; the largest of these was 17.58 meters between piers and the smallest 15.57 meters. The total length of the bridge between abutments was 117.88 meters, and its width between faces was 13.80 meters. The piers are 3.95 meters thick, and rest on piles.

In 1845 it became necessary to widen the deck. This was accomplished by utilizing practically the entire width of the original structure for the roadway, raising the pier heads to the level of the sidewalks and carrying the sidewalks on metallic arches.

These arches are semi-circular. Each rib consists of five cast iron sections bolted together. In cross section they are channels 450 by 135 by 50 millimeters, and are the same depth throughout the entire length of the arch. The spandrel work was cast in six sections, and is bolted to the arch ribs.

Pont Royal.—The Pont Royal was completed in 1689 and is composed of five semi-circular masonry arches; the center arch has a span of 23 meters, the adjacent arches 22.60 meters, and the shore spans 20.58 meters. The arches are 17.0 meters long between faces and carry a roadway of 10.4 meters and two 3-meter sidewalks.

The entire bridge is constructed of cut stone and rests on pile foundations. The depth of the arches at the keystone is 1.42 meters. The piers are 4.86 meters thick.

Pont de la Concorde.—With the construction of the Pont de la Concorde, in 1787, a new type of bridge was inaugurated, the segmental arch, which type was employed exclusively until the middle of the next century.

The Pont de la Concorde was designed and constructed by M. Peronet, Chief Engineer of Bridges and Highways under Louis XVI. It is composed of five segmental circular arches of masonry resting on four 2.92-meter piers and two 15.59-meter abutments. The pier footings are stepped out to a width of 6.82 meters and rest on timber platforms on piles.

The bridge is 15.59 meters wide between faces, accommodating a roadway 8.75 meters wide and two 3-meter sidewalks. The central arch has a span of 31.18 meters with a rise of 3.97 meters; the adjacent arches span 28.25 meters and have a rise of 3.69 meters; the shore spans are 25.33 meters long with a rise of 2.98 meters. The keystone depths are, for the middle, adjacent and shore arches, 1.09, 1.01 and 0.88 meters, respectively.

Pont Notre Dame.—The present Notre Dame bridge replaced a 6-arch structure built in 1499-1507 by the Joconde Brothers, an Italian religious organization. The type of foundation used in this bridge was the same as that employed later for the Pont Neuf, as heretofore described.

They are timber platforms laid directly upon the sand, but, unlike those of Pont Neuf, they were immediately enclosed in sheet-piling walls and further protected by loose rock dumped at the upstream ends.

In 1852 it became necessary to lower the roadway some three or four meters to conform to the new level of the streets approaching it, so it was decided to completely wreck the old superstructure and rebuild the bridge on the old foundations. Accordingly, the superstructure was demolished to a point slightly above the water line, and the piers rebuilt with a thickness of 3.5 meters. They were connected with five eliptical arches, varying in span from 18.76 meters for the largest to 17.40 meters for the smallest. The central arch has a rise of 7.5 meters and the shore spans 7.25 meters. The depth of the arches at the keystone is 0.88 meter.

The sixth arch of the old bridge had been built to span the head of a canal which was no longer in existence.

The length of the arches between faces is 21 meters, and the width of the deck 20 meters between parapets. The bridge has a 12-meter roadway and two 4-meter sidewalks.

For the greater part, stone from the old bridge was used, set in natural (Vassy) cement mortar.

The reconstruction required approximately one year and cost 713,000 francs.

These were the first elliptical arches used, beginning another new era in bridge construction. During the next ten years, six more bridges of this type were built.

Profitable Life of Fire Proof Office Building

Some interesting information on this subject is given in a recent Bulletin of the Building Managers' Association of Chicago, from which we quote the following:

No doubt, to the average person, a modern office building with its imposing and massive architecture is a structure built to last countless years which neither wear nor changing conditions can harm. Experience, however, shows this to be far from the fact, for even despite every effort to stay "old age" through repairs and rejuvenation, the inevitable element of obsolescence develops and cannot be overcome. Not always a pronounced physical deterioration, this condition is usually best explained by the term "old style." "Antique" is suggestive of increased values when applied to certain art objects. It means just the opposite when applied to office buildings. Nor need a building necessarily be old in years to be so regarded, for changing styles in architecture and continuous improvement in the physical features of newer buildings soon detract from the so-called modernity of buildings of earlier construction. Then, too, changing city conditions reflected often-times in greatly increased ground values and consequent high taxes may necessitate a standard of rentals unobtainable for the particular building in competition with more modern structures, thus making it an inadequate improvement for the lot. A change in neighborhood conditions may also shorten the profitable life of a building well-planned, and which when constructed was considered in the judgment of its builder to be a permanent investment. Or again, increased ground values may become so great as to make it necessary to build higher buildings than have yet been constructed.

Obsolescence, therefore, is a vital factor in the probable life of the average modern fireproof office building despite the fact that occasionally there may be found a building where age seems not to have affected its prestige and renting possibilities. Usually, in such cases, however, there will be present some special reason why the investment continues profitable despite the age or obsolete type of the building. Such cases cannot be used in a fair consideration of the general question.

What has happened in downtown Chicago in the past 35 years tells its own story of how "permanent" modern office buildings are with the passing of time. Look at this list of almost forgotten names of prominent office buildings which were removed (with two exceptions) after lives of less than 30 years to make way for another crop of more "modern-permanent" buildings:

Champlain Bldg., 15 stories, northwest corner Madison and State Sts. Erected 1894. Demolished 1915 (21 years).

Continental Bank Bldg., 10 stories, La Salle and Adams Sts. Erected 1884. Demolished 1912 (28 years).

Rand-McNally Bldg., 10 stories, Adams St. near La Salle St. Erected 1884. Demolished 1912 (28 years).

Trude Bldg., 14 stories, southwest corner Wabash Ave and Randolph St. Erected 1897. Demolished 1912 (15 years).

Royal Insurance Bldg., 15 stories, 160 W. Jackson Blvd. Erected 1885. Demolished 1920 (35 years).

Montauk Bldg., 9 stories, Monroe St. near Dearborn St. Erected 1883. Demolished 1902 (19 years).

Mallers Bldg., 12 stories, southwest corner Quincy and La Salle Sts. Erected 1886. Demolished May 1, 1920 (34 years).

Six directors prepared individual opinions, the consensus of which was that it is not safe from an investment standpoint to assume that the profitable life of even the best fireproof office building in Chicago will exceed from 30 to 40 years from the date of its construction.

Fabricating Shop Contracts in May.—The records of the Bridge Builders & Structural Society, from reports collected by its Secretary, show that during the month of May, 1921, 50,800 tons of fabricated structural steel were contracted for throughout the United States, 28 per cent of the entire capacity of the bridge and structural shops of the country.

Component Costs of Building Construction

Very little reliable information is available as to the proper values to be placed on the various component parts of a completed structure. At the national conference of the construction industries held last February at Philadelphia, Mr. Barclay White, a contractor, of that city, gave some information on this subject that should be of interest. An abstract of his statement follows:

The relative values of the various parts of the building have not been very carefully studied heretofore but we have made an attempt to fix an approximate proportion covering the whole building field in this territory. We have gone about this by taking a composite of building, which includes a reinforced concrete factory building; slow burning or heavy construction warehouse building with brick walls; the typical style of two-story dwelling; detached brick and frame residence; stone schoolhouse with wood floor construction; fireproof institutional building; the apartment house; and the steel frame office building.

How the Costs Were Arrived At.—From our own records of cost we have taken typical instance in each of these eight types of building and have divided it up according to the actual cost figures, into labor and materials, and have then tried to proportion the various types of building as nearly as possible, in their correct relation to the total volume of business which is done in this territory. Of course, right there you will realize that there is bound to be a great deal of leeway which should be brought out, for in the course of the last few years house building has fallen off very largely in proportion to the heavier types of construction. These figures will have to be taken as the best approximation that the circumstances permit.

After arriving at a makeup of the different types, and proportioning the various types into their proper ratios, we have summarized, for instance, the main item as skilled labor on the building. It is a little difficult to say where skilled labor stops and unskilled labor begins, but we have based the calculation on the mechanics on one side as against the apprentices, helpers, hod carriers and common laborers on the other side. The result of our calculation is given in Table I.

Our total for all skilled labor on the building, and including in that also the cost of all stonecutting, the shop work on stairs, mill work and sheet metal, aggregates 27.55 per cent on the cost to the owner of the average building. The unskilled labor is 9.44 per cent, these values are to be taken of course in dollars and cents, and not in number of men employed. The general supervision, and general engineering and estimating, will run 5.60 per cent, liability insurance is 1.41 per cent, bringing the total labor costs of the completed building, without including any of the fabricating or manufacturing labor, to 44 per cent of the total completed building.

Cost of Materials.—The most important item which we have to consider in studying the cost of building is labor. The materials have been similarly worked out, and taking these different types of building we find that 8.86 per cent is lumber; 6.10 per cent is brick delivered to the site; 5.93 per cent is structural steel delivered to the site, including, of course, the fabrication and so forth, which is done in the shop. Then we go on down to the boilers, heating and piping work, and work of that sort; 5.81 per cent, cement; 2.60 per cent, f. o. b. cars Philadelphia; hardware and nails, 1.78 per cent, sand delivered, which includes the sand in the concrete, masonry, brick work and plastering, 1.69 per cent; electric fixtures, conduit, wires and switches and all sorts of things in connection with electrical work, 1.6 per cent; stone, for concrete work, 1.49 per cent. There is an item here for sprinklers and fire protection, and that is a rather difficult thing to get at very accurately, and we have included some minor items, amounting to 1.04 per cent. Coming down the list of 1 per cent or less, we have building stone, paint, roofing, sheet metal materials, plastering materials, not including sand, roofing materials, lime, glass, cut-stone and terra cotta, elevators, mechanical equipment, tile and marble running down to 1/10 of 1 per cent. The total for materials is 42.88 per cent, or just a little less than the value of the labor on the job.

Overhead, Expenses and Profit.—There is really a duplication of overhead expenses and profit because possibly 65 per cent of the work is sublet, and on that work sublet to the plumber, the plasterer, the painter, etc., there is really a [illegible] the general [illegible] trades of the [illegible] make [illegible] with the [illegible] dividing the work [illegible] and overhead [illegible] per cent. The net compensation of the subcontractors, assuming they do 65 per cent of the work, 3.90 per cent, and the net compensation of the general contractor, assuming he does 35 per cent of the work, directs and supervises the balance, 3.42 per cent, bringing the total up to 100 per cent.

TABLE I—[illegible] PERCENTAGES OF [illegible] IN COMPOSITE BUILDING.

[illegible] building with stone walls, and a brick apartment house.

The relative importance of these different types of building in determining the figures for the composite whole, were determined by reference to the published lists of building permits and similar [illegible] relative importance of the various items in the make-up of the total volume of building business transacted in this territory.

Analysis in percentages of cost of a composite building, showing average values of various items for each $100 worth of building work normally done in Philadelphia district:

Labor—		
All skilled labor and supervision on the building, including also stone cutting, and shop work on sheet metal and millwork only	[illegible]	
Unskilled labor on above	[illegible]	
Office, estimating, general supervision and engineering salaries	[illegible]	
[illegible] insurance	[illegible]	
Total labor (no manufacturing except as stated)..		44.00%
Materials—		
Lumber for millwork, concrete forms and structure delivered at site	$8.86	
Bricks delivered at site	[illegible]	
Steel, structural, miscellaneous and reinforcement delivered at site	5.93	
Boilers, heaters, piping, etc., for heating	3.05	
Plumbing fixtures, piping, etc.	2.76	
Cement [illegible]	2.60	
Hardware, nails and similar misc. materials	1.78	
Sand, delivered to site	1.69	
Electric fixtures, conduit wire, etc.	1.60	
Stone, slag and pebbles for concrete	1.49	
Sprinklers and fire protection apparatus and other unclassified items	1.04	
Building stone	.90	
Paint	[illegible]	
Roofing and sheet metal material	.70	
Plastering materials (no sand)	.65	
[illegible] materials	[illegible]	
Steel sash, etc., delivered to site	.50	
Lime (no plaster)	.45	
Glass	.40	
Cut stone (materials) and terra cotta	.38	
Elevators delivered to site	[illegible]	
Mechanical equipment, cranes, etc.	.21	
Tile and marble (materials only)	.10	
		[illegible]
Overhead Expense and Profit—		
Office rent, taxes, interest, depreciation of equipment, general expense and overhead (not wages)		$ 5.80
Net compensation of all subcontractors (assumed as doing 65% of the work)		3.90
Net compensation of general contractor (assumed as doing 35% of the work, direct and supervising the balance)		[illegible]
		$100.00

Fire Tests of Building Partitions.—As a part of the work of the fire-resistive properties of building materials, a series of tests is being conducted on brick walls by the U. S. Bureau of Standards, Washington, D. C. A test specimen in the shape of a panel 11x16 ft. and 8½ in. thick is built into a heavy steel frame so that the whole can be swung into place in an oil-fired furnace of which the test panel then forms one wall. The panels are tested about one month or six weeks after completion, the test consisting in subjecting the panel to a severe fire during which the temperature of the furnace is increased in accordance with a predetermined program. The test is continued for 6 hours [illegible] in [illegible] temperatures reached at the end of the test are high enough to melt certain kinds of brick. Observations are made of the temperatures obtained at various parts in the brickwork and of the distortion of the panel caused by heating. Observations as to whether temperatures on the cool side of the panel become high enough to ignite inflammable materials, whether cracks or other openings develop through which the fire might penetrate, etc., are an important feature. So far none of the brick walls tested failed to remain in place during the 6-hour test although as fire barriers the heavy walls naturally proved superior. Several tests similar to those above described are being conducted each month. Engineers and architects or others interested in the details are welcome to visit the bureau to witness the tests; the exact dates on which the furnace will be in operation may be obtained by writing the Bureau of Standards, Washington, D. C.

Durability of Wood Not Affected by Time of Cutting.—Many of the theories advanced regarding the durability of wood attribute too much importance to the time of cutting, say specialists of the Forest Products Laboratory, Forest Service, Department of Agriculture. As a matter of fact, the time of cutting has very little effect upon the durability or other properties if the timber is properly cared for after it is cut. The method of handling logs at different times of the year, however, does influence their durability. Timber cut in late fall and winter seasons more slowly and with less checking than during the warmer months, and when proper storage or handling is impracticable, winter cutting is best. Fungi and insects do not attack wood out of doors in cold weather, and by the time warm weather arrives the wood is partly seasoned and somewhat less susceptible to attack. It is for these reasons that winter cutting is advantageous, and not on account of a smaller amount of moisture or sap in the wood in winter, as the popular belief has it. There is practically no difference in moisture content of green wood in winter and summer.

Bids to Be Opened July 30 for Bridge Over Yellow River in China.—The date of opening of the tenders for the construction of the railway bridge over the Yellow river for the Peking-Hankow line, scheduled for June 30, has been extended to July 30. The Chinese government received a telegram from Wei Chen-chu, Minister to Belgium, reporting that the Belgian adviser would not be able to leave Belgium until the middle of June and requesting a postponement of the date for the opening of tenders for another month. The Ministry of Communications complied with the request.

Personals

The Turner Construction Co., New York City, has opened a local office at No. 3 Giddens Bldg., Atlanta, Ga., with H. B. Pope as superintendent.

Dr. Walter F. Rittman of Washington, D. C., has been selected as head of the department of commercial engineering at Carnegie Institute of Technology.

Jacob L. Crane, Jr., who has been studying town planning at Harvard the past year, sailed on June 11 for a six months' trip through all the countries of Europe to study town planning and municipal affairs.

Louis Focht, engineer of the New Jersey State Board of Taxes and Assessments, has been appointed by Governor Edwards a member of his Delaware River Commission for the elimination of toll bridges across that stream.

William C. E. Becker, structural engineer for the Missouri Pacific R. R., and formerly professor of civil engineering at Washington University, has been appointed Chief Engineer of the Department of Public Safety of St. Louis.

The firm of A. E. Ponsford, Ltd., contractors, St. Thomas, Ont., has been reorganized under a Provincial charter as the Ponsford Construction Co., with a capital of $400,000. A. E. Ponsford is President of the new company; Herman Ponsford, Vice-President and Manager; Harley Ponsford, Secretary, and Bert Ponsford, Treasurer.

Obituaries

Elias B. Bascom, a building contractor of Lansing, Ia., died June [illegible] in that city, aged [illegible]

Frederick W. Collett, a consulting engineer of Cambridge, Mass., died suddenly June 17 in a sanitarium in Evanston, Ill.

Walter Wookey, a civil engineer of the Anaconda Copper Mining Co. at Butte, Mont., was killed June 8, when he was caught in [illegible] tailings at the slime pond. He was [illegible] years of age and had been a resident of Butte for more than 18 years, working at the Leonard and other mining properties there.

S. T. Morse, City Engineer of Carlinville, Ill., and formerly County Engineer of Macoupin County, was instantly killed June [illegible] when his automobile was struck by a passenger train at a crossing 3 miles south of Carlinville. Mr. Morse was 49 years old and was a graduate of the University of Illinois. He was well known for his work in connection with the design of concrete pavements, and was a prominent member of the Illinois Society of Engineers.

Industrial Notes

The Anti-Hydro-Waterproofing Co., Newark, N. J., has opened a local office at Room 1223 Land Title Bldg., Chestnut and Broad Sts., Philadelphia.

Col. Washington A. Roebling has been elected President of John A. Roebling's Sons Co., Trenton, N. J., wire rope manufacturer, succeeding his nephew, Karl G. Roebling, who died suddenly on May 29.

The Good Roads Machinery Co. will move its general sales office from 821 Bulletin Bldg., Philadelphia, Pa., to Kennett Square, Pa., on June 25. After that date all correspondence should be addressed to Kennett Square, Pa.

Foreign Engineering Review Quarterly Issue

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Roads and Streets—1st Wednesday
(a) Roads
(b) Streets
(c) Street Cleaning
(d) Municipal Miscellanies
(e) Management and Office System

Waterworks and Hydraulics—2nd Wednesday
(a) Waterworks
(b) Sewers and Sanitation
(c) Irrigation and Drainage
(d) Power and Pumping
(e) Management and Office System

Railways and Excavation—3rd Wednesday
(a) Excavation
(b) Management and Office System
(c) Quarries and Pits
(d) Steam Railways, Construction and Maintenance
(e) Electric Railway Construction and Maintenance

Buildings and Structures—4th Wednesday
(a) Buildings
(b) Bridges
(c) Harbor Structures
(d) Miscellaneous Structures
(e) Properties of Materials
(f) Management and Office System

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Invention and Labor

Editorial in The Engineer, London, May 6, 1921.

Mr. Balfour, speaking last week of the value of research, and incidentally pronouncing a blessing on the new Institute of Physics, said, in effect, that if labor would give up continual bickering over its present rate of wages and do its best to help industry, then science, in the course of a few years, would so facilitate and accelerate the rate of production and so harness new forces of nature that all men would be able to live in comfort with the expenditure of far less energy than at present and would have far more leisure to enjoy—if they knew how to enjoy it. No scientist will hesitate to accept Mr. Balfour's words. We all believe that the domains of science which remain to be conquered are as extensive as those already won, and though we can see but dimly into the future, yet every now and then some great imaginative intellect points through a rift in the cloud to the promised land beyond. Even labor itself, paradoxical as it sounds, has this belief in science. It does believe that invention can reduce its toil; it does believe that research can show it how to make two blades of grass grow where but one grew before; it does believe that "the engineer can do for a shilling what any fool could do for a pound." That it has the queerest way of expressing this belief we admit: but that it holds it is shown by its occasional outbursts against the lack of progressiveness in certain industries.

The influence of labor upon the scientific developments of industries is a chapter of history that has yet to be written; and an exceedingly interesting chapter it will prove to be. An example that jumps to the mind may be given to make plain our meaning. Let us ask ourselves to what condition American inventiveness would have now attained were slavery in that country still practiced. Had labor remained extremely cheap in North America, had it been very plentiful instead of scarce, would the labor-saving appliances for which the United States are famous have appeared? It is extremely doubtful that they would; it is more than probable that emancipation by increasing the cost of labor, coupled with the rapid development of new areas which caused the exhaustion of the supply of craftsmen, led to the multiplication of machinery for economizing manual power. If now we turn our eyes from the conditions of North America and glance at China we see the opposite condition prevailing, and find just such results as we should anticipate. There, with a dense population and extremely cheap labor which is barely removed from a state of slavery, invention has never been encouraged and is not welcomed, because it is not really needed. In Europe the conditions are halfway between those extremes. Labor was not very costly, and there is neither a dearth nor an excess of it. There is in normal times a small percentage greater than the needs, but it is so small that it does little more than balance the time expended by work-people in moving from place to place. And what do we find as a consequence? We find divided and uncertain opinions upon the value of labor saving; the work-people frequently opposed to it from fear that unemployment will follow in its train; the capitalist desiring it to just that extent and no more that will enable him to compete in the markets of the world with other nations that have cheaper labor or many appliances for reducing the labor cost per piece. We suggest that it is to these actions and reactions that we must look for an explanation of the attitude, on the one hand of labor, and on the other of capital, towards industrial science in the United Kingdom. Assuming that this conclusion is right, what must be the outcome of the desire of labor for higher wages and shorter hours? Were labor sympathetic there would be one reply. Desiring high wages and short hours, but recognizing that they would force up the price of commodities and so lead to the loss of markets and the destruction of industries, labor would encourage the introduction and discovery of means of economizing toil. Hence the inventiveness in which Britons are as rich as any people in the world, would be freely exercised until the total costs per piece could be brought down to a level at which competing nations could be successfully met. Unfortunately, there is a section of labor that will not or cannot take this long view. In spite of the fact that every page of industrial history shows that the introduction of machinery has led to the increase of em[illegible] in spite of the daily [illegible] every workman that he could not be fed, nor clothed, nor carried, nor housed as he is without machinery, he inherits from his forebears an ancient and illogical distrust, and whilst he desires all the comforts and conveniences that machinery brings, he yet opposes it from the fear that it may do what experiences show it never has done—cause unemployment and increase poverty. Could we but convince him of his error in this respect, then, as Mr. Balfour said, such comfort as he now dreams of—and illogically fights for—would be his for the asking. Every new step in science, industrial or pure, leads towards greater amenities, greater well-being, less labor, and more leisure.

Did the effect of this attitude towards technical progress begin and end at this point it would be bad enough. Unfortunately, it goes much further. The troubles in which labor has involved industries for many years past has prevented the accumulation of riches, which is the first step towards great developments, and has discouraged employers, who hesitate to make costly changes in their plant and machinery from uncertainty that they will be permitted to enjoy the fruits of their enterprise. Mr. Balfour appealed to rich men to help industrial research; but rich and poor are alike in this respect, that they will not give money nor lend money to industries which are in a continual state of unrest, and in which they cannot see, in the circumstances, profit to themselves or to their country. A few years of complete freedom from serious strikes would lead to a remarkable change. Our foreign trade could be recovered, and men, grasping the chance of making money, would hasten to invest in industries and to encourage research of all kinds. The great body of labor would share in the general welfare and be relieved from anxiety about unemployment, whilst opportunities would be opened to the more aspiring spirits to find their way up the social ladder. There is no greater need than that labor should be brought to see that its welfare is bound up with the growth and improvements of industries, and that it can win far more by encouraging invention, research, and progress than it can ever hope to attain by methods that hamper them.

The New Institute of Physics

Editorial in Engineering, London, April 29, 1921.

Touchstone defined a natural philosopher as one who knew that "the property of rain was to wet," a generalization which is daily confuted by the work of the lithographer. Nowadays this kind of knowledge is considered to be rather the mark of the craftsman, who often knows exceedingly well highly important scientific facts, but whose knowledge and interest stop there. The natural philosopher or physicist differs from the craftsman in that his province is to ascertain how it happens that water does not always wet, and the solution of such problems has for the most part been sought by him solely to satisfy an intellectual curiosity. Nevertheless such studies in their ultimate outcome have inaugurated a new age in the history of mankind, the age of energy which, inheriting the accumulated lore of the iron, the bronze, and the stone ages, which preceded it, has added a new factor which directly or indirectly has largely transformed the face of the globe and completely altered the intellectual outlook of mankind. When Queen Victoria ascended the throne in 1837 practically all educated people accepted without question the view that the world was only some 6,000 years old, whilst today, the physicist, by a study of the "sequelæ" of past radioactivity is able to date certain rocks as laid down as least 100,000,000 years ago.

On the material side the change has been equally startling. Intercourse between man and man has been increased, and the ultimate outcome will certainly add not merely to the material comfort of mankind but will most certainly also raise his ethical standard, which in one particular at least stands higher than ever before in human history. Wanton cruelty is far less prevalent than at the dawn of the present age, and is a direct outcome of the greater facilities now available for the interchange of thought.

It is true, of course, that the changes in question have for the most part been due to the engineer, but if it be his province to direct the great forces of Nature to the use and benefit of mankind, it is the task of the physicist to ascertain the nature of these forces and the character of the mechanism at work, when the component parts are too minute to be perceived save by the scientific imagination.

In this country, owing largely to the narrowly specialized instruction provided in our schools, the value of the work of the physicist was long appreciated by few. Up to the outbreak of the war, the Treasury (controlled in the main by the half-educated product of Oxford) were far from liberal in the value they attached to scientific knowledge. In frequent instances the salary they offered to expensively-trained graduates in science was of the order of £3 a week. When the Germans made their assault on Western civilization it took no little time to convince the Departments of State that something more than the possession of a good literary style was necessary to defeat the raid. In the end, however, the physicist and the engineer were called in—inadequately and imperfectly, it must be admitted—but, nevertheless, effectively, and amongst the principal factors, in our ultimate but hardly-won success, must be reckoned the contributions made by our physicists. As one result the number of physicists has greatly increased, and whilst twenty years ago, almost up to the outbreak of the war, few students of science could hope for anything but a badly-paid teaching career, the demand for their services now exceeds the supply, although the number available has enormously increased and is estimated by Sir J. J. Thomson to be 800 to 1,000 today. The time is therefore apt for more completely organizing this body of workers, and in the Institute of Physics a start is being made with 300 members, the president designate being Sir J. J. Thomson, who, as Prof. Bragg aptly said at the meeting, had for years constituted in himself a British Institute of Physics, his magnificent work at Cambridge having played a large part in bringing the study of science into the esteem in which it was held today. The inaugural meeting of the new Institute was held on Wednesday last at the Institution of Civil Engineers.

In his address to the meeting, Sir J. J. Thomson recalled the fact that when the Cavendish laboratory was founded at Cambridge in 1873, the original estimate for buildings and equipment complete was £6,300, and he further stated that right up to 1914 the cost of new apparatus required for research work never exceeded £400 in any year. This fact is the more striking in view of the revolutionary and fundamental character of the discoveries made, which are out of all proportion immensely more important than the voluminous investigations characteristic of the extremely liberally-equipped and endowed laboratories of the Fatherland. This fact emphasizes the truth of an observation made by Mr. Balfour, who attended the meeting in his capacity of Lord President of the Council and official head of the Department of Scientific and Industrial Research. Mr. Balfour made the point, to which we have repeatedly called attention in our own columns, viz., that you cannot ensure work of fundamental importance by increasing the number of your investigators or the lavishness of your equipment. Men of genius are born, and a great scientist can no more be created by education than can a great poet. Nevertheless, as Sir J. J. Thomson pointed out, even the pioneer is helped by the work of the mass of scientific hodmen. The promulgation of any new creative idea is necessarily followed by a period of suspense in which its implications are tested by comparison with experiment, and the bulk of this work requires little but intelligence, honesty and a reasonable amount of ingenuity on the part of the observer. This work requires time, and the more workers that are available, the less is the period which must elapse before the new contribution to human thought is fully assured, and the ground cleared for another move forward by the pioneers. The great difficulty in the way of increasing our army of workers is the financial one. When the Cavendish laboratory was first inaugurated the equipment was small, but so were the number of workers, and as one consequence a student could be sure of retaining necessary instruments till the end of his studies. As the number of students increased, this happy condition of affairs terminated, and as Professor Bragg said, investigators had to copy the example of the temple builders described in Nehemiah, and conduct their work with "their trowel in one hand and their sword in the other." Otherwise, they were likely to find missing some essential part of their plant.

Owing to our present poverty, the Treasury has had to cut down the grants appropriated to scientific research, but

Mr. Balfour said that this had been done most reluctantly, as it was recognized that no possible form of expenditure promises to yield a richer return to the nation. If, he said, our industries expended half as much energy in increasing the natural productivity as they did in quarrelling over the distribution of the present relatively feeble gains, there would be not merely an immense improvement in the material well-being of the nation, but there would also be much greater leisure for all, a condition which could be nothing but beneficial, intellectually and morally, provided always that men learnt to use it wisely, which as matters stand is too infrequently the case. Education only can supply a remedy.

The qualifications for members of the new Institute of Physics will be high, but it is hoped that some 800 to 1,000 members may be secured within the next year or so. There will be two classes of members, viz., associates and fellows, the former will be required to pass an entrance examination, or some recognized equivalent, and to have had, in addition, a year's approved research or manufacturing experience. Fellows will have to show a record of five years' experience either in research or in a position requiring a thorough knowledge of physics. The entrance fee will be respectively one guinea and two guineas for the two classes, and the annual contributions will be the same amounts. The secretary is Mr. F. S. Spiers, of 10, Essex Street, Strand, London.

Examination of Stresses in Structural Members with Polarized Light

Editorial in The Engineer, London, April 1, 1921.

It was Professor Luigi Luiggi, of Rome, who found "le mot juste" in the discussion on Professor Coker's noteworthy paper at the Institution of Mechanical Engineers two weeks ago. Professor Luiggi is an inductive philosopher. Bare mathematics and pure reasoning on the Greek model do not satisfy him. He likes experiments that appeal to the senses. He wants to see what is happening, and it is just that that Professor Coker's beautiful optical method of examining stresses enables him to do. It was because the slides which accompanied the paper showed the actual stresses, it was because the physical facts were put before them, that he admired the research. The slides were complementary to the mathematics. Mathematics alone were never quite convincing. There might be something wrong with them, they might start from a wrong premise, and then the conclusion would be wrong, but no one would ever know. Professor Coker was able to show that the mathematics were right; he showed it by actual physical means which left no doubt in the mind and gave a reality to the mathematics which without the optical proof they lacked. If we may venture to put Professor Luiggi's view in a brief form, it is that the wedding of a sensible fact with mathematics is always fruitful.

For our own part we are bold enough to go even further than the Italian philosopher. It seems to us that in the particular problems that were under Professor Coker's examination—contact pressure stresses and tension stresses in a bar of special form—the scheme of the distribution of the stresses is so much more important than the precise magnitude of the stresses that the latter may be neglected by the engineer engaged in practical work. Consider, for example, this case. It is desired to support a flat-ended column upon a plain block of metal. Hitherto it has been assumed that if the surfaces are flat the stress in the base will be equally distributed. Professor Coker showed that it was very difficult to get the surfaces—at least those of the celluloid he employs—so truly flat that this ideal condition is obtained. As a rule, he found that if two similar surfaces were pressed together there were high stresses at the corners. The easiest way of removing these variations of stress was to interpose a strip of rubber between the surfaces. Engineers, and particularly bridge builders, we need hardly remind our readers, have followed that plan for many, many years. Where it is necessary that the ends of a girder should bed accurately on a bolster or supporting piece, a sheet of lead is frequently interposed. Whether the introduction of lead sheet used in this way came about as the result of failures due to local exaggerated stresses, we cannot say; but it is evident that the effect must be to cause equal distribution of the stress. A fact of that kind, we say, is far more valuable to practical people than the ability to calculate the stresses if they are not equally distributed. Now that Professor Coker has shown us, by a method there can be no gainsaying, that it is not as easy as we thought it was to get perfectly equal pressures all over a surface, and, furthermore, that the interposition of a flexible layer will remove the inequalities, we shall take more care to get the surface truly flat or where need commands, and circumstances permit, shall introduce a soft layer between the hard faces. In brief, we shall take steps to avoid the higher stresses, and, as a consequence, the means of measuring them will cease to interest us. Again, when we come to tension stresses in test pieces on which collars are turned to facilitate the use of the extensometer, it is of interest to get visible demonstration of the distribution of stresses in the neighborhood of the collar and in the collar itself. But these highly localized stresses, even when they are intense, have little or no practical effect. In Dalby test pieces, the high local stresses which occur just at the fillet of the collars do not make the specimens break there; the majority break in the central region, like plain test pieces. Or, again, it may be quite true, as Dr. Hele Shaw indicated, that high stresses are set up in the region immediately surrounding the supporting surfaces under a beam and in the region of the load; but it would appear that such highly localized stresses are immaterial—the common law that the strength of a beam is measured by the square of its depth remains true. Hence, it may be said that, whilst it is deeply interesting actually to see the stresses, there is nothing in the investigation of such simple structures to disturb the engineer, nothing, in fact, that it is worth his while to calculate.

Much of the work done by Professor Coker with polarized light has been devoted to the examination of the stresses in structures of "built-up" outline—a lattice girder, for example—and in such cases his method has given and will continue to give information which is of direct practical value, but in the case of simple forms, we may say, without the least disparagement, that its greatest value is educational. On the one hand, it provides, as Professor Luigi Luiggi pointed out, a physical proof of mathematical investigations, on the other, it shows that secondary stresses of considerable magnitude which escape mathematical study may be set up. In simple forms those stresses appear to have little or no effect, but in complex forms they might have immediate importance or they might have importance that increased with time. Professor Coker, to take a simple example, showed that a little area of high stress occurred at the fillet in the Dalby test piece. Though that stress is so local that it has no effect during the breaking of a specimen, it is at least conceivable that the area would increase under long sustained load, until it assumed dangerous proportions. Hence, in complex figures it is important to recognize the existence of these little areas of high stress, and an examination of the reasons for their occurrence should prove profitable. We are glad to know that it is the intention of the Institution of Mechanical Engineers to reproduce some of Professor Coker's slides in their natural colors, for they bring home to the observer the actual distribution of stresses with a distinctness and certainty that cannot be reached by mathematics and geometry.

Engineers and Civilization

From an Editorial in The Engineering Review, London.

Engineers are among the most appreciative readers of the scientific romances of H. G. Wells, and they will probably need little inducement to study the series of articles by this writer in the Sunday Times on "The Salving of Civilization." These articles were originally prepared as lectures to be delivered in the United States and Canada. They reveal very clearly Mr. Wells' appreciation of the engineer as a master force in the work of civilization. History is usually written as if the marriages and divorces of kings, the passing of certain laws, the waging of war, and the conflict of ecclesiastical institutions were the prime movers of human progress. Mr. Wells, however, goes beneath all these superficial elements. "The international problem today," he declares, "is essentially dependent upon the question of transport and communication—all others are subordinate

In the [illegible] last hundred [illegible] has been a complete alteration in the range and power of human activities; "men can react upon men with a rapidity and at a distance that was inconceivable a hundred years ago." America owes most to the acceleration in locomotion, but has felt it least; the railway, the river steamboat, the telegraph and so forth were taken as a natural part of its growth, although in point of fact they came just in time to save American unity. Europe, on the other hand, owes least to the revolution in locomotion, and has felt it most. The limits of European states were drawn by the horse, and, as they had become final and conclusive, every extension involved a war. "It is as if," writes Mr. Wells, "some rather careless worker of miracles had decided suddenly to make giants of a score of ordinary men, and chose the moment for the miracle when they were all with one exception (the United States) strap-hanging in a street car."

Some Suggestions for Prevention of Water Waste

[illegible] Municipal Engineering and Sanitary Record, London, March 31, 1921.

The prevention of waste of water, which is a matter of paramount importance to the majority of water undertakings, is by no means solely a question of house-to-house inspection and the re-washering of leaky taps. The discharge of water through any orifice varies directly as the square root of the head, or of the pressure, and it is frequently easy to reduce the pressure during the night hours, even if not throughout the whole twenty-four hours. A reduction of pressure from, say, 49 lb. to 36 lb. per square inch would reduce the leakage by over 14 per cent, and could probably be effected without seriously impairing the fire services or the efficiency of the general supply. Again, if the public were more fully informed upon the subject by means of circulars or Press notices, they could be brought to realize that water costs money, and that the more water they waste individually the higher must the cost be. A regular periodical house-to-house inspection will always bring to light leakages in the fittings that can easily and quickly be rectified but to which the occupier pays little attention owing to the trouble of either procuring a washer and fixing it himself, or of arranging for someone else to do it. The trouble of re-washering taps could be very materially reduced by the insertion of a few extra valves on the services when they are first put in. The more important leaks as regards the quantity of water wasted occur in the underground distribution system outside the buildings, and it will generally pay to keep an inspection staff constantly at work. The leaks are easily located by those accustomed to the work by the use of a stethoscope or aquaphone. At night, when traffic has ceased, the sound of escaping water may be detected at a distance of 200 ft. or 300 ft. A bad leak may be traced by sounding along the roadway directly over the pipe line, although the sound does not carry so far, nor is it so distinct as a metal-to-metal sounding. A small leak from a service pipe under a pressure of 50 lb. or thereabouts makes a sharp ringing sound; a broken main usually makes a vibrating or rattling sound. A bad break on a low-pressure pipe is difficult to detect by sound, especially if the water can readily flow away through underground channels, as it only gives a low rumbling sound that can be easily mistaken.

Chartered Civil Engineers

[illegible] Engineering Supplement, London, April, 1921

The Institution of Civil Engineers is now proposing to seek a supplemental Royal Charter to give its members the use of the professional description. "Chartered Civil Engineer," in the belief that this term would soon become a mark of professional civil engineering status. The council of the institution is without doubt in a position to be suitably advised on the subject, and must necessarily be aware of the difficulties with which the application of such a measure will be met. The purpose of the institution is "the general advancement of mechanical science," but the profession of a civil engineer, while it does not always require the full extent of knowledge that is included in this purpose does in some respects require more. The knowledge that is actually necessary in a civil engineer is there- [illegible] that needed from those who practice specific branches of engineering, and in particular the extent of practical experience that he should have is a matter in which opinions will differ widely. If the institution succeeds in obtaining the charter it seeks it will find itself accordingly bound to collect and represent a sufficient consensus of opinion among qualified civil engineers to make sure that its claims are respected by the profession generally and have the intended result. It will also have to consider how to reconcile the claims of the proposed charter with those of the charters which for the protection of their members would no doubt be sought by other engineering institutions.

Electrolysis as Applied to the Measurement of Water

From Water and Water Engineering, London, March 21, 1921.

The following is a brief description of the electrolytic water meter invented by Mr. G. F. Shotter. This instrument uses the weir, or notch, principles for obtaining the flow of water. Instead of the well-known float, which is generally used, a fixed apparatus, without moving parts, is placed in the notch compartment in such a position that the true height of the water over the notch is measured.

Let it be imagined that two rectangular plates, or grids of copper gauze, are placed in the water a definite distance apart, and that an electrical battery is connected, in series with an ammeter, to these plates. It will be realized that as these plates are covered with water (the water being the electrolyte), so the electrical path is increased, and consequently the current flowing, as recorded by the ammeter, also increases. Now, if these plates were of such dimensions and located that, at no flow over the weir, they were just touching the surface of the water, and that at full flow they were submerged, it is obvious that the current flowing would be directly proportioned to the height of water passing over the weir.

As is known, the flow over a weir is not directly proportional to the height of water, and therefore the readings, as indicated by the ammeter, would be of very irregular ordinates. Moreover, any variation in electrical conductivity of the water would give a wrong indication of the height. To overcome these disadvantages, a specially cut trough is made, into which a positive plate is fitted in the center and a negative plate at each end. A further addition is made by the use of what is known as a standard path.

This standard path is of circular cross section, with three plates, as the other path, but it is always submerged in the water. It will be appreciated that, if all electrical indications are compared with the indications on the standard path, some true record is obtained. To do this, and thus obtain an immediate indication of the flow of water, an instrument known as the "ratiometer" is used. As the name implies, this instrument gives the ratio between the current passing in the variable path and the current passing in the standard path, and, by design, the flow of water is recorded directly.

Mr. Shotter has an actual model working, which he used recently in a lecture delivered before the Junior Institution of Engineers. It represents an installation in a large manufacturing firm. The robustness of design, and the entire absence of moving parts in the water, was noted on this occasion, and it was evident that the instrument is automatically of the distance-transmission type, which has been so much sought after for many years. With this instrument it is quite feasible to record the flow of water any distance from the actual weir or notch by merely running the necessary electrical cables.

In a power station, the condensed steam passing from a condenser can be read on the switchboard, obviously a much more suitable place than that which is necessary with a float or other type of water meter. Moreover, any leakage of circulating water into the condensed steam can be easily detected by a change-over switch on this instrument. The example shown at the lecture gave, on test, an accuracy of 0.5 per cent. The demonstration proved the apparatus suitable for the measurement of water, particularly for waterworks, sewage disposal works and power plants, especially those using the "close circuit" system of condensate.

Method of Lengthening a Tunnel on the Great Western Ry., England

From The Engineer, London.

The Parsons Tunnel, which is situated on the main line of the Great Western Ry. between Dawlish and Teignmouth, is in course of being extended for a length of 147 yards, with the object of protecting the line from the possibility that, as continued weathering takes place, stones might fall from the cliff, which at this point rises to a height of 200 ft. above rail level. The railway where the tunnel is situated immediately adjoins the coast, and the foundations of the abutments of the new work have been carried down to beach level and founded on rock. They are constructed of concrete below rail level, while above that level they consist of concrete faced with brick, averaging 14 in. thick, and carry a semi-circular brick arch five rings thick. The railway near the tunnel is carried on an embankment protected from the sea by a retaining wall, and where the new tunnel walls closely approach the sea wall, as they do for a length of 200 ft., the space between the two has been excavated and filled in solid with concrete, and the sea wall has been thickened on the front to take the thrust of the arch. Fig. 1 is a typical cross section through the thickened sea wall. It is, of course, requisite for the work to be carried out without serious interference with the traffic, and that has been accomplished, except that trains have to run at a reduced speed.

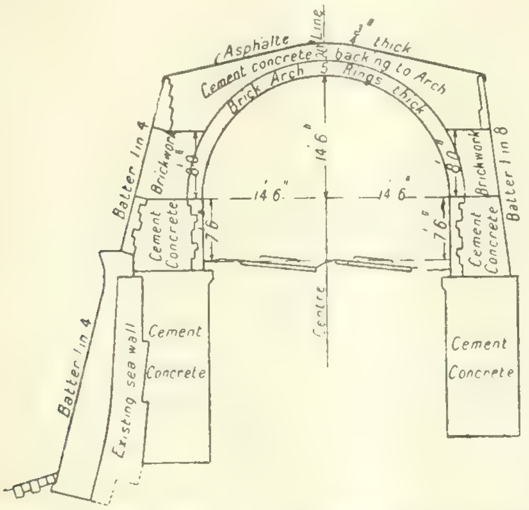

Fig. 1—Cross Section Through Thickened Sea Wall.

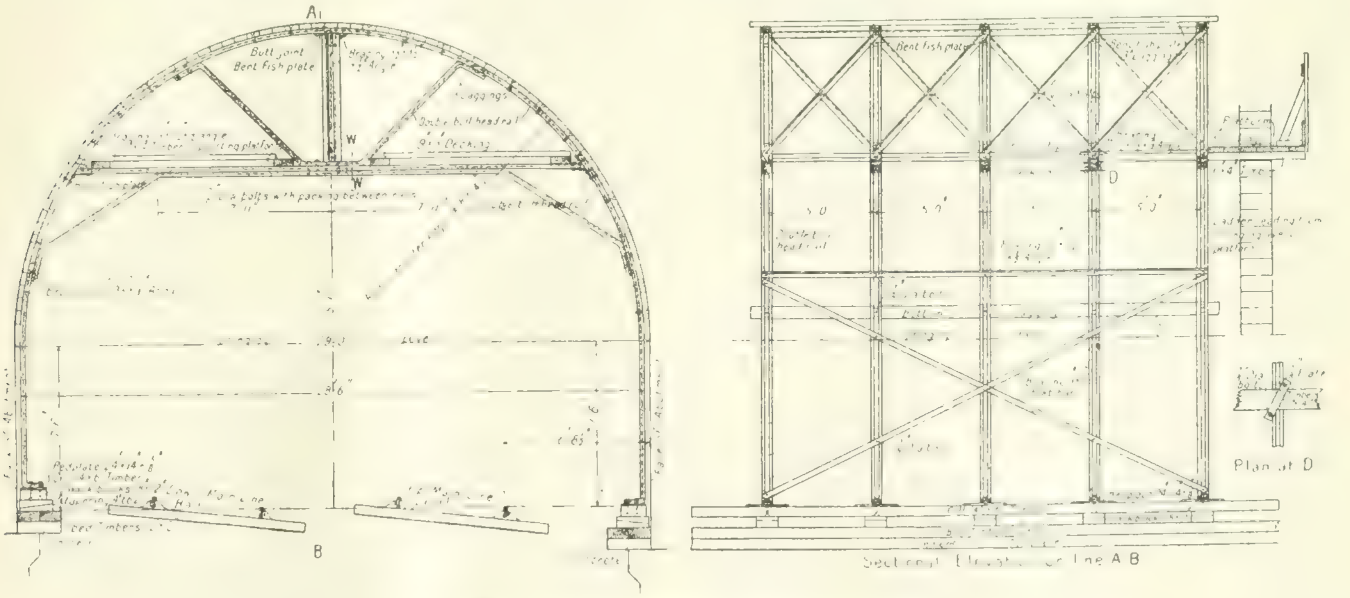

Fig. 2—End View and Sectional Elevation of Shield.

A shield of sufficient height to allow its underside to clear the company's maximum load gauge is being used for the purpose, and it acts as a center for the building of the arch. The shield is 20 ft. 6 in. long over all, and it is made up of five ribs each weighing about 35 cwt., which are placed at 5 ft. centers. The ribs are constructed of second-hand double bull head rails, curved as required, bent fish-plates and ⅞-in. bolts being used to make up the connections. Where the rails abut directly upon one another as at W, W in Fig. 2—packages are inserted between the webs—as shown in Fig. 3—so as to make what is practically a solid and rigid bar. The bracing connecting the ribs consist of 3½ in. by 3½ in. by ½ in. angles and 3 in. by ½ in. flat bars all bolted to the ribs by ⅞ in. bolts. The angle bar bracing between the main posts is fixed diagonally, the remaining angle bracing running horizontally the full length of the shield, while the flat bars connecting the lower part of the ribs are fixed diagonally across the shield from end to end.

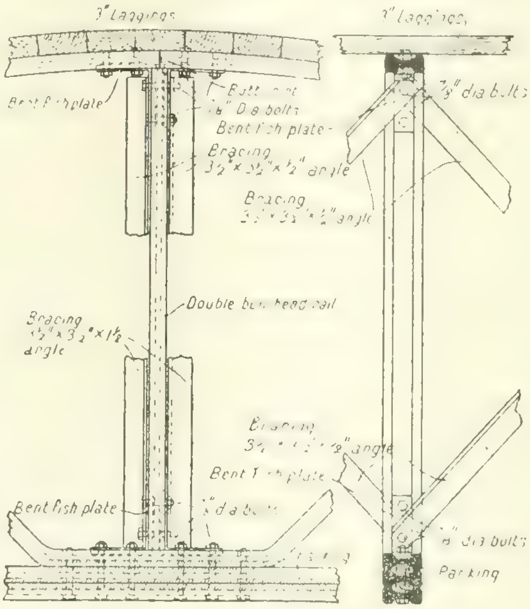

Fig. 3—Centre Post and Bracing.

The sill is composed of one 14-in. by 6-in. timber fixed to the heels of the ribs by ⅞-in. bolts, which are countersunk on the underside of the sill, a bed-plate ⅝-in. thick between the heel and the timber sill completing the connection. To ensure a solid bed for the shield to rest on, concrete 6 in. thick, partly supported by the footing of the foundation, was put in at each side outside the outer rails, and it was made of sufficient width to take two 12-in. by 6-in. timbers.

[illegible] are bedded down and [illegible] as to ensure smooth running of the rollers, which are used when moving the shield forward, and also to provide a solid bed for the lifting jacks to rest on. Slack blocks, which can be easily removed when required and which render any adjustment of the shield found necessary a simple matter, are placed between the bed timbers and the sill directly under each rib.

A timber platform is fixed on the leading end of the screen as a protection to the line during building operations, as well as to permit of easy access for the men from one abutment to the other. This platform is carried by four 11-in. by 4-in. timbers which rest on the main bracing of the ribs and are tied down to the second rib from the leading end by plates and bolts. Figs. 2 and 3 show the construction of the shield in detail; the timber platform referred to being shown in Fig. 2.

Each rib was delivered in three sections, the periphery portion being in two sections, and the bracing and center post complete making up the third section. Consequently, the only work to be done on the site was the attachment of the bracing to the periphery of the rib. The shield was erected on a Sunday, occupation of one line only being necessary, a traveling steam crane being used to carry each rib forward and place it in its allotted vertical position. The sills had previously been got into place, and the time taken to erect the shield complete, exclusive of leggings, was about ten hours.

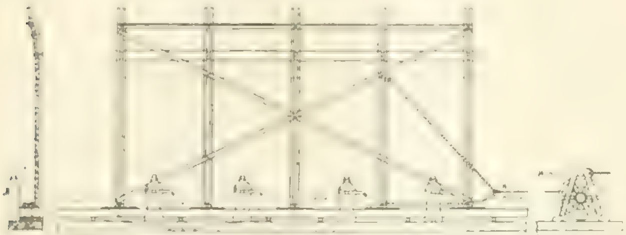

Fig 4—Arrangement of Jacks, Rollers and Winches for Moving Shield.

Before moving the shield forward it is lowered approximately 3 in. on to the rollers already referred to; these are iron pipes plugged with wood, six on either side, spaced as near as possible at equal distances over the length of the sill. Four lifting jacks—Haley's patent—are used for lowering and raising. They are fixed in suitable positions over the length of the sill and screwed up just sufficiently to take the weight and allow of the removal of the slack blocks. The shield is then lowered on to the rollers and pulled forward by hand winches. Fig. 4 shows the position of jacks, rollers and winches, also the fixing of the chain attachment to the shield. The chains fixed as shown ensure that the shield shall move forward on an even keel; an operation which can be carried out during the week and without interference with the traffic.

The work is under the supervision of Mr. W. W. Grierson, the company's chief engineer; the actual construction being carried out by Mr. F. A. Brown; Mr. E. G. Matheson being resident engineer.

Timber as Reinforcement for Concrete.—A few years ago the idea of using wood for the purpose of reinforcing concrete was embodied in a patent granted to Mr. G. O. Case, who subsequently read a paper on the subject before the Society of Engineers. Quite lately Signor Viscardini, an Italian engineer, has been considering the employment of wood for the same purpose in reinforced concrete beams. The reinforcement proposed consists of longitudinal strips of timber, nailed together at the ends and at intermediate points, and placed suitably for resistance to tension in the lower part of a beam. Stirrups for resistance to secondary stresses are formed of vertical strips of wood, sometimes nailed to upper longitudinal strips serving the double purpose of keeping the stirrups in place and of acting as compression reinforcement. The vertical members can be utilized further by allowing some of the lower ends to project through the under surface of the concrete, where they act as plugs for the attachment of ceilings and fittings.—From the Times [illegible]

Lead Poisoning and Water Supplies

By JAMES F. READE.

From Water and Water Engineering, London, March 21, 1921.

There are two distinct ways in which water acts upon lead. The more important, because more often producing evil results, is known as "plumbo-solvency." The second is called "erosive ability." The uncertainty frequently experienced when reading reports dealing with the behaviour of water in contact with lead would be materially diminished if a proper distinction were drawn between these two reactions, and if it were made clear whether the case was one of plumbo-solvency or lead erosion. Plumbo-solvency, as the name implies, is that power which some waters possess of dissolving or assimilating metallic lead.

The reagents mostly used for the detection of lead in water are ammonium sulphide, calcium sulphide, and sulphuretted hydrogen. Dr. Thresh gives us the following as the most satisfactory method of testing: To 100 cu. cm. of water add a drop of freshly prepared calcium sulphide solution faintly acidulated with hydrochloric acid. Lead sulphide is formed which gives a color ranging from faint brown to black brown; 0.05 mg. of lead can be detected in this way.

The most serious outbreaks of lead poisoning have been observed in connection with public water supplies derived from moorland gathering grounds of a peaty character. When waters from such sources give indication of plumbo-solvent ability, they are almost invariably found to be possessed of a certain slight acidity as an accompanying condition.

Lead Poisoning and Public Water Supplies.—The natural features of gathering grounds vary so much, not only as between those in different localities, but also on one and the same watershed, that the impossibility of laying down detailed rules for the guidance of engineers who may have to make inspections will be recognized. The object of the survey must be kept prominently in view—namely, to obtain such data as will guide in the formation of an opinion of the probability of the water from the gathering ground giving rise to lead poisoning. A very important governing factor in this matter is the proportion of acid water entering the supply. It may therefore be helpful to mention a few of the features which control acidity, and how they influence it, and the consequent condition of the water relative to its plumbo-solvent ability.

Features Which Control Acidity.—The nature of the underlying rocks and those forming the beds must be carefully studied. Spring water alone is rarely plumbo-solvent. Contact with certain rocks, as when a stream runs over a rocky bed, may be sufficient to cause a water originally acid to become neutral, or soluble salts taken up from the rocks may confer and intensify acid neutralizing power sufficiently to resist the influence of a considerable influx of acid water and prevent the acquisition, by the mixture, of lead solvent power. On the other hand, a neutral spring water may become endowed with solvency power by an access of acid water from a peaty area. Moist peat is invariably acid.

The relative proportion of peat bearing and non-peat bearing area in the catchment is of great importance; the presence of peat being the chief factor in the production of acidity, the figures should be obtained with a fair degree of accuracy. The whole drainage area may be further subdivided into bogland, moorland, or land of a peaty character, pasture land, tillage land, etc. Not only the surface area, but the quantity of peat existing, which depends on the depth as well as on the area, must be ascertained. It is essential to obtain information as to the length of time the rainfall remains in intimate contact with the peat. Steepness or otherwise, especially of the peat area, is a prominent factor governing this, the discharge being facilitated or retarded according to the slope. Prolonged contact or stagnation, as in bog holes or marshy places, always produces acid water, while rapid discharge minimizes acidity. Each rainfall displaces in succession water which has been stagnating perhaps for a considerable time. This leads up to the question of rainfall, not so much regarding quantity as its manner of precipitation. A steady rain giving a continuous flow from a peaty area is less likely to produce a high degree of acidity than the same amount of rainfall precipitated as a heavy downpour which, coming after a period of dry weather, washes out stagnant acid water. As the distribution of rainfall varies with the seasons the chances of getting a highly dangerous water at one time and a perfectly safe water at another must be duly weighed; and what might be considered as a normal state of things, because prevailing without noticeable change during protracted periods, may be altogether upset by weather and seasonal variations. The quantities of water flowing off the respective areas must, of course, be carefully estimated as well as the yield and variations of springs, which, as above indicated, have a very direct bearing on the ultimate result.

Land producing an active growth of grass is never more than partially peaty in character. Water draining from it is either neutral or only very feebly acid, and the more free the soil from peaty matter the less likelihood there is of acidity in the water yield. Bare rocky ground seldom produces acid water.

Other Factors Which Generate Acidity.—There are other factors besides peat which generate acidity in water, thereby investing it with plumbo-solvent ability. The oxidation of iron pyrites is perhaps the most important of these, although its occurrence is rare and necessarily limited to localities where the mineral forms a constituent of the rock. Acidity absorbed by rain water during its fall through the atmosphere is another source of lead solvency. The entrance of an acid water from whatever source, even in a comparatively small quantity, may be the means of supplying the overbalancing influences required to push to danger point water already on the border line. Acid water of any kind must be carefully watched.

Thus the ultimate state of a water yielded by a gathering ground, in respect of its acidity, may in general terms be said to depend on the relative proportions of peaty, spring, and other neutral or acid waters present, as well as the mutual powers of implanting its own character or the liability to be neutralized with each kind may become endowed with from time to time.

The property known as "erosive ability" is probably inherent in greater or less degree in all waters. Its action may be compared to the rusting of iron. A relatively insoluble compound—oxyhydrate—is formed which scales away, leaving a fresh metallic surface open to attack. The process is therefore progressive, the water continuously manufacturing, as it were, a lead compound which disseminates throughout the liquid.

Control of Plumbo-Solvency.—Under the ordinary working conditions of a water supply there are two circumstances which inhibit erosive action of the lead pipes and fittings. The metal, before being laid in the services, etc., must necessarily have been exposed for a time to the atmosphere, during which it acquires, naturally, a protective coating. Again, nearly all waters, in their passage through or over ground, take up substances which are capable of forming an insoluble layer on lead surfaces which shields the clean metal from contact with the erosive water. Thus a water very often carries with it the means for its own protection. The field of action is therefore much more limited than that for solvency power.

The usual test for erosion is made by placing a small strip of bright lead—say, 1 in. by ½ in.—in a test tube and covering it with a measured quantity of the water to be examined. If erosive ability is present a milkiness near the surface of the strip becomes sooner or later perceptible and quickly diffuses throughout the liquid. Later it will be deposited as a white powder at the bottom of the test tube. The quantity of lead taken up in a given time can then be estimated by the ordinary laboratory methods. Should the water contain substances which inhibit erosive action, a bluish-white insoluble coating is formed on the bright strip and no cloudiness appears. Pure distilled water is commonly found to erode lead vigorously. But anaerobic conditions, an excess of sodium carbonate, chalk, or limestone have been found to counteract the erosive power. Rain water and snow water are strongly erosive. Waters flowing off open gathering grounds, especially from moorland and peaty areas, very often possess marked erosive ability, and, as a general rule, are found to possess "erosive proximity," while hard waters from limestone are generally very remote from the ability to erode lead, due, no doubt, to the substances acquired in their passage through those rocks which confer protective ability.

Methods of Treating Water Supplies for Plumbo-Solvency.—The water supplies of several towns in the North of England are treated for plumbo-solvency by somewhat elaborate methods, powdered chalk, lime, or carbonate of soda being added to and mixed with the water by machinery. Such processes have been called "hardening," probably by way of contrast to the well-known water softening measures carried on elsewhere. The term does not seem a very expressive one; for although the treatment does confer some slight increase of hardness, the result is only incidental, the real object being not to harden the water, but to neutralize its acidity. In dealing with plumbo-solvency, the simplest and perhaps the best system of treatment is that by which the water is neutralized during filtration through ordinary sand filters. A thin layer of lime is spread on the filter surface and renewed as required, or the coarser parts of the body of the filter may be constructed of broken limestone.

Remedial treatment for erosive power must be carried out thoroughly. It would also appear that the proper time for definite treatment is after filtration, which always causes a change in water, especially by the removal of suspended matter. This may have a good or ill influence on self-protective ability. So that the beneficial results due to the presence of certain substances before filtration may be diminished during that process, or tendencies adverse to the desired salutary effects may be developed.

Failing the practicability of entire elimination as mentioned in connection with plumbo-solvency, treatment with carbonate of soda is the most convenient and effective means of providing the condition of "erosive remoteness." The proper way of applying it, and that which accords most closely with what has just been explained, is by "hardening" the water first through some form of lime treatment. Then, after filtration through sand and limestone, carbonate of soda should be added in sufficient quantity to leave a slight excess above what is required for neutralization. Water so treated will be in a safely remote state.

Test Results Upon Reinforced Concrete Slabs

From the Engineering Review, London

In order to obtain some definite data upon this subject a sub-committee was formed by the Concrete Institute some time ago, firms interested in the high-tensile reinforcements being represented.

A paper upon the results of tests conducted by this Committee was recently read by Mr. H. Kempton Dyson before the Concrete Institute, and should be studied in detail by all interested in the subject.

The tests were made at the Manchester College of Technology; the following table gives the summary of results of the slab tests:

Slab mark.	Actual area of steel used in square inches.	Working moment of resistance in tension in inch pounds	Ultimate moment of resistance in inch pounds.	Actual factor of safety in tension.
A	.854	75,800	272,200	3.59
B	.854	75,800	278,700	3.67
C	.7575	64,300	235,200	3.65
D	.743	64,300	229,100	3.56
E	.6057	65,100	183,600	2.81
F	.6077	67,460	176,900	2.71
G	.5892	63,700	251,500	3.95
H	.5892	63,700	247,900	3.89
J	.5892	63,700	249,100	3.91
K	.5892	63,700	260,600	4.09
L	.589	63,500	309,200	4.86
M	.589	63,500	297,200	4.67

Test results upon reinforced concrete beams and slabs

Slabs A to D were reinforced with mild steel bars, calculated at 16,000 lb. per square inch; slabs E and F had shell discard steel calculated at 20,000 lb. per square inch; G and H had "spiral band" bars calculated at 20,000 lb. per square inch; J and K "indented bars"; and L and M drawn-steel wire calculated at the same stress.

The Biological Sterilization of Sewage.—Dr. Calmette, of the Pasteur Institute, has shown recently in a lecture before the Council Superieur d'Hygiene Publique that the septic tank's action is not complete by itself, and recommends the addition of a special filter. In this filter the overflow of the septic tank will be oxidized by extended contact with the air. In this way the "aerobic" bacteria complete the sterilization work already started by the "anaerobic" bacteria in the septic tank.—From Municipal Engineering, London.

The Projection of Maps

[illegible] 1921 [illegible] in [illegible] published by [illegible] Society, 1920

The subject of map-projections has always been a thorny one, mainly because the writers who have investigated the theory have dwelt in different spheres from the map-makers who have had to make practical use of the projections. The two classes have possessed moreover no weights and measures in common: the mathematician estimates the value of a projection by means of different systems of errors; the map maker's ideas of value are governed by such considerations as simplicity, economy, uniformity with his other projections, possibilities of future expansion, and the general utility of the finished map. It is at times a question whether to subordinate utility to mathematical accuracy or vice versa. The problem has been deemed worthy of study by some of the most eminent mathematicians of history, but the surveyors who work upon maps have neither the power nor the leisure to scrutinize theories. The co-operation of two different classes of men is thus required. The projection of maps may be likened to the erection of a column in architecture; the mathematical theory forms the base, the map forms the capital. The base by itself is useless, the capital is the architect's aim.

Although the subject of map-projection has been exhaustively dealt with by numerous writers, there are very few books that can be said to have successfully bridged the gap between the mathematician and the map-maker, between the base and the capital. Authors harass students with descriptions of numerous projections that have no practical use; they do not sufficiently explain the particular employment for which each of their many projections may be considered suitable; and they close their investigations before they have crossed the border-line between theory and practice.

The author of the book under review was Deputy Surveyor General of the Malay States, and the map-maker would expect to receive from him a helpful exposition. But Mr. Young is a skilled mathematician, and his book leans more to the mathematical side than to the practical. As an investigator Mr. Young deserves to rank with the eminent authorities of the past; his knowledge of theory is exceptional, and he is one of the few living authors who can be fairly regarded as experts. But his absorption in the scientific side of the problem, and his pleasure in grappling with mathematical difficulties have led him to curtail the practical side to such an extent that the professional map-maker will derive little advantage from his book. This is to be regretted; the map-maker is in want of a post-war exposition of useful and employable projections, and it would be difficult to find an author more qualified by experience to write one than Mr. Young.

Mr. Young has displayed much originality in his new treatment of the conical projections, but his descriptions of his own original steps are so abbreviated that he will not receive the credit he deserves. His plan of altering the scale error at the centre of the map in order to reduce the average scale error is the most valuable contribution that has been made to the subject for years.

Many surveyors have to work with rectangular co-ordinates and to consider the convergency of meridians: Mr. Young's references to these points are too brief. His new method of reducing the errors of the Cassini projection is useful and shows a grasp of the subject, but its novelty is not sufficiently emphasized.

An illustration of the want of unity between mathematicians and draughtsmen is to be seen in the conservative retention of Mercator's projection in modern atlases. Whilst the mathematician has been discussing the complexities of obscure projections, the draughtsman has continued to employ a projection which falsifies geography and which ought never to have been used for educational purposes.

The chief practical difficulty of the past has been due to the great number of projections, which have been thrust before the map-maker for his selection. He will therefore be astonished to learn from Mr. Young's book that the very best projection of the conical class was one invented in 1758 by the Rev. Patrick Murdoch and which has been subsequently forgotten. Whilst this projection possessing all the virtues has been allowed to sink into oblivion, many projections without any virtues at all have been continually brought to notice.

Another feature of Mr. Young's book will come as a surprise to map-makers. The latter class have always accepted the results presented to them by eminent mathematicians without question. But Mr. Young repeatedly points out mistakes in the mathematics of the highest authorities. According to Mr. Young (page 2) Sir George Airy "made a slip in his solution" and "Airy's erroneous tables have unfortunately been incorporated in later publications." Mr. Young also shows (page 4) that Clarke made an error in his calculations, and (page 72) that Jordan's formula was wrong, and (page 75) that even Helmert's formulae for convergency were incorrect. Each of these mistakes may have been individually unimportant, but their cumulative effect is disconcerting. All these mathematicians were surrounded with computers, and their work could have been checked before it was published.

No discussion of map-projections is now complete unless it refers to the changes which the views of geographers have undergone since the end of the nineteenth century, when the Paris conference issued its recommendations for an International Map of the World. Old-established mapping offices were then led to look into the projections which they had inherited and which they had hitherto reverenced as the mystic symbols of ancient wisdom. Their examination showed that a want of understanding had separated the mathematicians and map-makers of the past. The utility of a map had too often been subordinated to mathematical difficulties. A geographer now realizes that he only requires three projections in order to make good maps of a whole continent; he requires one projection for his small-scale geographical maps, another for his topographical maps on all their various scales, and a third for his revenue surveyors who have to work with rectangular co-ordinates.

The definite recommendation of the polyclinic projection by the International Conference brought more light to mapping offices than the technical treatises had done. This projection is becoming widely adopted for maps on various scales. The advantages of having maps on the larger scales all fitting into the smaller are great; projections are becoming unified, margins made coincident, overlaps eliminated. Co-operation in a map of the world is moreover teaching a surveyor to look beyond his own borders; he can no longer give to his projections such final limits, as his predecessors were apt to do; he must allow for possibilities of expansion.

Mr. Young discusses the "best" projection for a long narrow country like Italy; by "best" he means the projection that will show a minimum error. But a question, that will occur to many map-makers, is whether any map of Italy will be found satisfactory if it excludes the Alps, the Adriatic and Sardinia; if these areas are included, Italy can no longer be regarded as a narrow strip. Moreover the Italian Survey has already adopted the polyconic projection for its maps on the scale of 1/million, and this step may render the same projection convenient for other scales.

In discussing the "best" projection Mr. Young does not mention the scale of the map, which he is contemplating. The problem for the best projection of a given area is dependent to a certain extent upon the scale of the forthcoming map. One projection may suit a wall-map on a scale of thirty miles=one inch, and another projection may be more suitable for a large scale map (one mile=one inch) published in numerous sheets.

The conical projections, as they are generally understood by geographers, have their pole corresponding with the pole of the Earth, so that meridians of longitude are directed towards the pole of the projection. Dr. Hammer has suggested conical projections, in which the pole of the projection does not correspond with the Earth's pole. An artistic cartographer will dislike the mathematical conception of a cone placed askew on one side of a spheroid, and his objections will have Mr. Young's support. The latter writes that "when the pole has a skew position the map has an ugly appearance," and that the only "useful" position is when the pole corresponds with the Earth's pole. Hammer's idea is thus vetoed on practical grounds.

Graphical Method for Determining the Proportions of Reinforced T-Beams

By G. IVAN COPE.

From Engineering, London, Feb. 25, 1921.

The accompanying diagram presents a rapid and accurate method for determining the size and quantity of steel necessary in a T-beam, for a given bending moment. It has been derived from the formula and fundamental principles given in most text books, and it will be found that the results correspond to those obtained by the slower and more tedious method otherwise necessary. Furthermore, it has the advantage that the most suitable and economic results can be selected by observation, since by tracing the curve representing any variable, the corresponding dependent value can be seen. Any error which is due to the difficulty in reading the curve to a finer degree of accuracy is inappreciable.

In designing a T-beam, the thickness of flange, being the superimposed slab, is already known. It is then necessary to find what depth to make the beam so that the stress in the concrete is not too high. At the same time it should be remembered that the deeper the beam is made the less steel is required, which therefore reduces the cost up to a certain point, depending upon the relative cost of concrete and steel.

The bending moment and thickness of slab being fixed the curve enables one to select varying depths, showing for each case, the stress in the concrete and the percentage of steel required.

In order that the use of the curve may be clearly followed, a short description showing the method of procedure is given, and examples worked out. The curve is based on the stress in the steel being 16,000 lb. per square inch, and the ratio $\frac{Es}{Ec} = 15$.

When the bending moment M and depth of slab d s are fixed, the remaining unknown variables are:

The compressive stress in the concrete (c).

The depth of beam (d) and

The steel ratio (p).

When one of these is fixed the other two can be found.

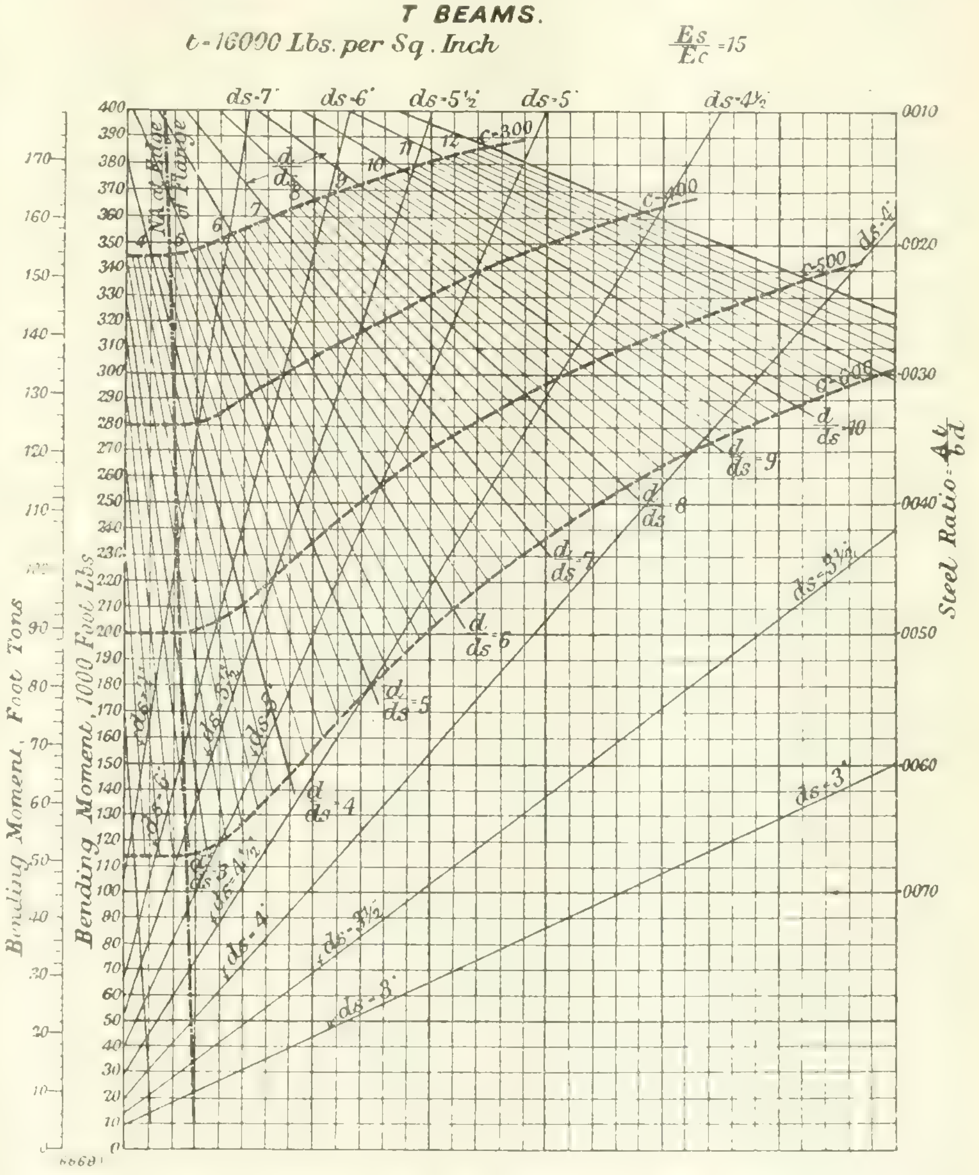

Diagram for Use in Determining Size and Quantity of Steel Necessary in a T-Beam.

Enter the curve on the left at the computed value for M. Travel horizontally until the known value of d s is cut, from this point travel in a vertical line up or down, then any point on this line gives three readings: c, $\frac{d}{ds}$ and p. Take a point, then its relative position between the dotted lines gives the value for c, $\frac{d}{ds}$ is read by taking the value of whichever line, radiating from the top left-hand corner, is cut, and p is read horizontally on the scale shown on the right-hand side.

Take an example:

A bending moment of 200,000 ft.-lbs. and

A 4-in. slab.

From the junction of the lines representing these two values, travel vertically up until the dotted line representing c = 600 lb. per square inch is met, then $\frac{d}{ds} = 7 \therefore d = 28$) and $p = 0.0043$ and $A s = p b d \therefore A s = 0.0043 \times 48 \times 28 = 5.76$.

Travel further up until the line representing $\frac{d}{ds} = 11$ is met (that is d = 44), then read c = 370 and p = 0.0017 ($\therefore A s = 0.017 \times 48 \times 44 = 3.59$.

This curve is worked out for cases in which the breadth of flange b equals 12 times the thickness of the slab. If a smaller breadth must be used, the computed bending moment must be increased in the ratio of the decrease in breadth, and the new value for the bending moment gives the required depth, compression in the concrete, and the percentage of steel.

Taking the foregoing example, but considering a breadth of flange equal to 36 in. instead of 48 in., then $M = 200{,}000 \times \frac{48}{36} = 266{,}667$ ft.-lb.

Therefore for c = 600; d = 35 and $p = 0.0036 \therefore A s = 4.53$ and for $\frac{d}{ds} = 11$ or d = 44; c = 460 and $p = 0.00226 \therefore A s = 3.58$.

It will thus be seen that results can be obtained in a minimum space of time, especially when one becomes familiar with the different variables. In short, for any given bending moment various sections and their other dependent values can be obtained at a glance, and from these the most suitable can be selected.

Suggestions on Town Planning

[illegible] London. [illegible]

[illegible] address was deliv[illegible] Henry E. Stilgoe, M. Inst. C. E., on the occasion of his installation last Friday in the presidential chair of the Town Planning Institute.

Many idealistic views, said Mr. Stilgoe, were put forward by town planners, and while some of these views would a few years ago have been looked upon as extravagant, fortunately for the country, people were taking a wider view of town development, although there was still much to be desired in this respect and greater knowledge was necessary.

Necessity of Broader Consideration.—In the preparation of town-planning schemes it was necessary to take the widest view of the situation. It was worse than useless to plan even a small area without first considering its effect upon the locality as a whole. Those of them who had to prepare schemes for the planning, replanning and development of great cities, the improvement of their traffic facilities, the transport of the population between their homes and their work, housing, education, recreation, etc., know how very necessary it was to consider an area as a whole, not only in relation to itself, but regionally.

Lack of Planning Requires Changes.—It was essential to give primary consideration to the great arterial roads, the connecting roads, and the secondary roads with a view of affording the best means of road communication to the various districts, and thus relieving the lesser or estate roads of much traffic which inconsiderate laying-out often imposed upon them. By this means the requisite widths could be assigned to the various classes of roads, thereby enabling the lesser or estate roads to be constructed more economically. One saw day by day the evil of that reprehensible form of planning which had left us with narrow main streets, and what was as bad, or worse, the building forward even to the fore-court lines, in front of existing buildings. The method of prescribing frontage lines under the powers possessed by the Birmingham Corporation was a very convenient one; it did not necessitate the carrying out of the work in a scheduled time, there was no stipulation to purchase existing buildings, and the lines of street laid down upon the plan might not be encroached upon by new buildings or any other erection. The work could, in fact, be proceeded with as building development or rebuilding took place, or when it was considered necessary to acquire the vacant land.

Street Widening Problems.—In discussing the width of arterial roads, one was often met by the objection of cost. There appeared to be a common idea that ample width and cost were inseparable.

Let it be borne in mind that when widening a street which was already built up, compensation for disturbance would have to be met in any case, and it often happened that the buildings fronting such a street had served their day and were but a poor veneer to even worse property in the rear, which, to provide for an extra width of streets and valuable frontages for resale, could be purchased at relatively little extra cost. In the case of widening an old road in the suburbs or a more rural district where no buildings fronted upon it, the cost need not be considered. The land could often be obtained for 1s. or 1s. 6d. per square yard. The actual works of construction on the added width of the suburban arterial road could be deferred until traffic and building development demanded it. The essential point was to obtain or earmark the land, and to see that new buildings were set back to the line laid down upon the plan.

Subdivision of Roadway.—In the planning of the arterial road and the allocation of its width to various purposes—e. g., tramway track set apart from the carriageways, the carriageways and footpaths, etc.—adequate width should be assigned to the footpaths or spaces between the carriageways and the forecourts, in order that the mains, and in some cases the sewers also, might be laid therein, and thus avoid the expense of disturbing the carriageways. If due attention were paid to this matter, very large sums of money could be saved in the upkeep of the carriageways, and a great deal of inconvenience avoided. The same remark applied to adequate provision for the width of footpaths and spaces in secondary, and even in estate streets, while as to the space reserved for an independent tramway track, this would well repay its provision even if a surface tramway was not constructed; the popular means of conveyance, whatever it may be, would require width, the space could be used for ornamental purposes, and it might eventually become the site of a tramway subway.

Economic Adaptation of Areas.—The skill and preception of the engineer, proceeded Mr. Stilgoe, were particularly necessary in considering the adaptation of the area to the various requirements of a scheme. There were many instances of land which, by reason of its level or location, could not economically be developed for building purposes. This, however, might be suitable for playing-fields, open spaces, river walks, or allotments, and should be reserved for such in the general scheme.

The most economical sites for building estates were those which could be developed without too great an expenditure upon earthworks, and which could be sewered and supplied with water, gas and electricity without undue cost in the extension of the trunk sewers or mains. A great deal of expense in estate development could be obviated by a careful scheme of sewerage, prepared in consultation and agreement with the local authority. On more than one large estate in Birmingham special agreements were entered into by which the sewers were laid at the rear of the houses, thus effecting a saving in the length of the house connections, the corporation's interests being safeguarded by clauses in the agreements by which power of entry for renewal, repairs, maintenance, etc., without compensation, was reserved to the corporation. The same forms of agreement were applied to some of the service mains.

The selection of factory sites, added the president, was a very important matter, and should be exercised with due regard to railway and canal facilities, to the amenities of the neighborhood, and to the convenience or accessibility of the workers.

Improved House Design.—A very important and pleasing feature in connection with town planning was the greater consideration given to the design of houses for the working classes. The old "tunnel-back" house did not find favor with the modern designer, and there was much more regard for convenience, sanitary arrangements, baths, etc. More attention was also being paid to aspect and to obtaining the maximum of sunlight in the principal rooms.

Speculative Building Approved.—Unfortunately, owing to a combination of circumstances, the operations of the speculating builder met with a very serious check just at the time when better designing was coming into vogue, and there had been very little progress in cottage building during the war. This was much to be deplored, as there was little doubt that the speculating builder would have adapted himself to building the required types of houses.

Co-operation Necessary.—The present activity in the preparation of housing schemes made it particularly necessary to give the fullest consideration to their effect upon the planning of the district, and to see that they fitted in with and were a part of the general scheme. Many of the London housing schemes had come into his hands in connection with the provision of water mains. These he had examined with great interest, and he had had conferences with some of the authors which had led to mutual help. In some cases where the estate to be developed abutted upon an existing arterial road, it was evident from the lack of provision for widening the road that there was no co-operation in this respect. He knew well the difficulty of making one town-planning scheme harmonize with another in the same locality, even when one had the will to do so; much more was it the case when the preparation of a comparatively small scheme was carried out with regard only to itself and without relation to a skeleton plan of the district. Having prepared five town-planning schemes covering over 25,000 acres in the city of Birmingham, his experience had been that one's views were widened as the work proceeded, with the result that some of the earlier work had to be brought into harmony with the later.

Sewage Grease as Fuel.—The Surveyor, London, of May 27, 1921, reports that an experiment is being made with the grease extracted from the sewage matter at the Esholt sewage disposal works of the Bradford Corporation, which can very easily have an important bearing on the fuel question. Hitherto the extracted grease has been sold by the corporation to merchants who have used it for the manufacture of various commodities, but now a test is being made to ascertain the practicability of using it for firing boilers.

Standardization of Disinfectants, with Special Reference to the Chemical Sterilization of Water

By MAJ. S .R. CHRISTOPHUS, DR. K. R. TYENGAR AND LIEUT-COL. W. F. HARVEY, I. M. S.

From the Indian Journal of Medical Research, 1920.

The standardization of disinfectants is practically universally carried out by means of the Rideal-Walker method or one of its modifications. The method is the well-known one of bactericidal effect in relation to time of action, and is carried out under defined conditions.

Many criticisms of the method have been forthcoming, chiefly concerned with the relation of the test to presence of organic matter. It has been suggested, for example, that in order to obtain a result in which presence of organic matter was taken into account, sterilized pus, faeces, urine, etc., should be added.

It will assist in making clear the reasons for some suggestions we give in this paper for modification of the test (with special reference to water sterilizing substances) if we very briefly note what are the conditions now generally used to determine the coefficient for a disinfectant by the Rideal-Walker method. It is essential to any standard test that it should be capable of repetition by various workers under exactly the same conditions, and in the Rideal-Walker method this is aimed at by the employment of the following standards (Hewlett, 1914):

The time intervals at which the effect is noted are 2½, 5, 7½, 10, 12½, and 15 minutes.

The test is usually made with a broth culture of B typhosus, but other organisms may be employed (e. g. B. coli communis.)

Comparison with a Standard Disinfectant.—The disinfectant used is 1-100 carbolic acid. The carbolic acid used in the Rideal-Walker test, as described in a war office memorandum, is: "Carbolic acid prepared by distilling Graesser's pure acid and rejecting the first distillate and residue, the intermediate portion being reserved and tested by melting point for purity." According to Hewlett, the carbolic acid used should have a melting point of not less than 40°, and should be kept in the form of a 5 per cent stock solution, standardized by the bromine method. In practice it may not be possible to obtain carbolic acid of these specifications. Samples of carbolic acid obtainable on the market are of variable character and the standardization of such differing samples is itself a matter of consideration.

In considering whether there was not some substance that might be used, having advantages over carbolic acid (especially as a standard for comparison with substances employed for the sterilization of water), we thought that iodine might be such a substance.

(1) In iodine we have an element very easily obtained in a pure form.

(2) The making of an accurate standard solution of iodine is a matter of direct weighing, and as iodine has no tendency to absorb water no special precautions have to be taken, as in the case of carbolic acid, in this respect.

(3) Since the substances most commonly used for the chemical sterilization of water are of the halogen group, a more homologous standard is likely to be obtained with iodine in suitable dilution than with carbolic acid.

For determining the coefficient of disinfectants used in the chemical sterilization of water (some of them proprietary preparations of unstated composition, but mostly containing chlorine), we have therefore employed iodine as the standard for comparison.

In addition to the use of iodine in the place of carbolic acid there are certain other modifications which, as will be seen later, are not merely obligatory, but essential, if coefficients obtained for members of the halogen group are to have any real significance whatever.

Use of a Broth of a Standard Composition.—In order that the culture used may be of a standard organismal content, a broth is employed with the following composition:

Lemco	20 grms.
Peptone	20 grms.
Salt	10 grms.
Water	1,000 c c

standardized to a reaction of +10 (Eyre's scale).

We were fortunate in having a quantity of Witte's peptone with which to perform our experiments, but possible difficulty in obtaining peptone suitable for the test is a matter to be taken into consideration, as the use of peptones of different characters is admitted to be liable to vitiate the result.

Whatever may be the position of the Rideal-Walker coefficient in regard to its suitability as a final measure of the practical disinfecting value of a substance in the presence of organic matter, we consider that, in the first instance at least, it is necessary to compare the action of disinfectants simply upon the bacteria themselves. If the disturbing effect of extraneous organic matter is to be determined, it is preferable that an additional coefficient in regard to this point should be separately arrived at. In the Rideal-Walker technique, however, the action of the disinfectant is not ascertained in the absence of organic matter, for peptone and other substances contained in the broth are present. The necessity for the presence of such substances is evidently merely dependent on the method used for obtaining a standard bacterial suspension.

The Addition of a Fixed Quantity of Culture.—The culture used is a 24-hour culture of B. typhosus or B. coli in the special broth. The quantity commonly added to a given amount of disinfectant dilution is 0.1 c. c. Along with the organisms there is obviously added a certain quantity of the constituents of the broth, amounting as regards organic matter to about 0.004 grm.

It would seem evident that what is required in the test is a suspension of organisms without lemco or peptone. This may easily be obtained in 0.85 per cent salt solution from an agar slope. The suspension is standardized by means of an opacity scale such as that described by Brown and Brown and Kirwan. This scale has the advantage, moreover, of expressing opacity in terms of weight of bacterial substance in the desiccated condition. By substituting such a suspension for the broth culture it is possible to avoid the presence of organic matter other than bacterial substance itself in the test. In our earlier determinations suspensions were made in the usual way by the addition of salt solution to an agar slope culture. It was found, however, better to make a suspension from growth scraped off and shaken up in a separate tube of salt solution. The suspension we have used, except for special purposes, is one containing the equivalent of 1.0 mgm. dried bacterial substance to the cubic centimeter. Of this 0.1 c. c. is added to 3.0 c. c. of the disinfectant dilution.

The standard procedure for the carrying out of the test has been employed by us in all respects except those noted.

Coefficient of Disinfecting Power of Iodine and Chlorine.—The only estimation of the coefficient of iodine we have been able to find is that given by Martindale and Westcott,* employing the Lancet modification of the Rideal-Walker test. This gives the effective limit of dilution of iodine as 1/50,000.

Our own determinations, using the unmodified Rideal-Walker method, show, as a result of repeated determinations, a maximum effective dilution of 1/5,500. In performing the test it was noted that the tubes containing dilutions, when tested at the end of the experiment, gave a blue color with starch solution up to, but not beyond, the particular point at which sterilization had been effected (1/5,500). Absorption of free iodine had evidently taken place in all the dilution tubes, and it was only at the point in the series where this absorption had failed to remove all the iodine that sterilization had occurred. The amount of absorption was found to be approximately that which occurred from the presence of the added broth constituents, so that the determination of a Rideal-Walker coefficient by this method appeared to mean nothing more than that so much organic matter (peptone and lemco) had required a particular quantity of iodine to be added before any was left free to act upon the organisms present.

The determinations made with a standardized suspension containing the equivalent of 1.0 mgm. dried bacterial substance to the cubic centimeter gave as the limit of dilution for effective sterilization by iodine 1/200,000. On using a suspension of one-tenth this bacterial content (0.1 mgm. per c. c.) the limit of sterilization was raised to 1/250,000.

The Rideal-Walker coefficient for "available chlorine" as given by Martin is 146-220, or dilutions of 1-14,600 and 1-22,000. Our own determinations with standardized suspension of 1.0 mgm. per cubic centimeter of salt solution show sterilization up to 1-300,000.

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*The Extra Pharmacopœia, Vol. 2, 16th Edition, 1915.

[illegible] the limits of sterilizing [illegible] purposely [illegible] the statement [illegible] of iodine [illegible] there is no difference [illegible] the different intervals up to the 15 minutes at which the experiment terminates.

Absorption of Iodine and Chlorine by Bacterial Substance.—The amount of iodine absorbed by given quantities of bacterial substance in a given time was determined. The amount of such absorption was considerable and various estimations gave for 7½ minutes a value of from 0.08 to 0.11 grm. of iodine absorbed by 1 grm. of bacterial substance, depending upon the strength of the dilutions used and concentration of the suspension. In the dilute proportions used in the test there is a difficulty in making precise estimations owing to the fact that the presence of a certain amount of iodine is apparently required to give the blue test with starch in any given water and the exact relation of this minute quantity to sterilizing effect it has not been possible to determine.

Approximately the dilution at which sterilization will be found effective in the test when using a standardized bacterial suspension in salt solution was found to be given by the amount of iodine required to satisfy the absorbing power of bacterial substance present. To make this clearer we may reconstruct the conditions of the test as follows:

[illegible] substance added [illegible] grm
[illegible] required [illegible]
[illegible] of bacterial [illegible] grm.
[illegible] the required [illegible] sterilization will be one third of this quantity per c.c., or 1-300,000 approximately.

Discussion.—Hewlett describes the Rideal-Walker method as "an admirable one for determining the relative efficiencies of disinfectants on naked organisms in the absence of organic matter." It will be seen that, on the contrary, in the method as frequently employed, there is a very important consideration, viz., the existence in the experimental tubes of substances, peptone, lemco, etc., having possible combining powers with the substances to be tested and deflecting the action of the disinfectant from the organism to such an extent, in the case of the halogen group, as largely or completely to vitiate the result.

In the modification we have employed it appears to us that we have a more satisfactory coefficient which does actually indicate the effect of the disinfectant on a definite quantity of naked organisms in the absence of organic matter.

But in reporting upon the value of a disinfectant there are quite a number of considerations that ought to be taken into account. It does not follow necessarily that a substance giving the highest coefficient in regard to sterilizing power upon naked organisms is the best. Other considerations may come in, such as efficacy of the material in the presence of organic matter, relative price of the material in effective dilution, stability, etc. In the war the question of portability naturally had great weight. Bleaching powder, for example, had the great advantage of portability but the great disadvantage of rapid deterioration and of a corrosive effect upon metal receptacles. A solution of bleaching powder (hypochlorite) standardized by titration satisfied the condition of sufficient stability for the purposes required, but was bulky for transport purposes. Again, we have found that a water disinfectant sent to the Central Research Institute for test contained a mercury salt, so that the element of poisonous character should also be indicated in the case of disinfectants used for such purposes as water sterilization. To sum up, the best type to report upon a disinfectant is one giving the determination of a number of coefficients.

(1) Coefficient of efficacy. Determined on bacterial suspension in salt solution.

(2) Coefficient of availability. Determined in relation to organic matter.

(3) Coefficients of stability, price portability, poisonous character, etc.

In regard to the halogen group with which we are now mainly concerned, it is possible by our method to give quite useful figures in regard to any proprietary substance claiming special value as a water sterilizing preparation.

Conclusions.—(1) The suspension of organisms used in testing disinfectants should be one of naked organisms in a menstruum containing no organic matter; special coefficients should be devised for the evaluation of the effect of organic [illegible]

(2) The quantity of organisms contained in unit volume of the suspension is a necessary datum in the evaluation of [illegible]

(3) Iodine is a better indicator to use (at all events for the testing of water sterilizing substances) than the commonly used carbolic acid; it has several advantages over carbolic acid which might render it preferable to carbolic acid in other cases than that mentioned.

(4) Coefficients of stability, price, portability, poisonous character, etc., are required to complete the description of a disinfectant.

Reinforced Concrete for Ship Construction

By PROFESSOR THOMAS BERTRAND ABELL.

From Engineering, London.

The paper places on record particulars of tests on and the general experience gained with concrete and reinforced concrete used in the construction of concrete sea-going vessels designed and built under the direction, first of the Admiralty and, subsequently, of the Controller General of Merchant Shipbuilding during the years 1917 and 1918.

The concrete was of rich mixture varying from 1 part of cement with 2.67 parts of mixed aggregate, to 1 part of cement with 3.66 parts of mixed aggregate. The aggregate consisted of natural gravel or crushed stone passing through ⅜-in. square or ½-in. round holes. The crushing tests show a wide variation in strength. It became clear there was no disadvantage in using a well-rounded, smooth beach gravel as aggregate. Better results were obtained with such an aggregate than with an angular aggregate. Good grading of the aggregate, together with extra fine grinding of the cement, were always found advantageous.

Density of concrete is important for ship construction, since the weight of the ship without cargo is an important factor in determining the dimensions of the ship. The extreme variation in weight per cubic foot amounted to 10 lbs., involving nearly 7 per cent. variation in the weight of the hull structure.

Bending tests were conducted on reinforced-concrete beams to determine (1) The value of concrete under tension; (2) the comparative value of round bars and different types of wire rope for reinforcement; (3) the behaviour of concrete under alternating stress: (a) At a stress less than that corresponding to rupture under tension; (b) at a stress greater than that corresponding to rupture under tension.

The beams for the alternating tests consisted of hollow cantilevers of rectangular cross-section erected vertically. Their lower ends were fixed in the ground, and the upper ends were subjected to an alternating force having a frequency of 4 to 7 (complete reversals) per minute. The calculated stresses in the concrete during the experiments were 180 lb. and 360 lb. per square inch. The cantilevers were filled with water so that evidence would be forthcoming directly the concrete on the tension side was completely fractured. Cracks were produced after a time with the tensile stress as low as 180 lb. per square inch.

The noteworthy feature about the tests was the eventual sealing of cracks through which water had been percolating. Whether the sealing was due to further hydration of the cement after grinding under the alternate opening and closing of the crack was not determined, but the cracks remained tight and were only reopened on increasing the load. The total number of reversals was 200,000 on one beam and 100,000 on a second.

Further tests were made to determine whether concrete could be placed on a practical scale in thin slabs so as to act as a container for heavy oil fuel of high flash-point, and also for petrol. There was no difficulty in regard to the heavy oil, and though with extreme care concrete containers might have been made to retain petrol, it was decided that the risk would be far too great to enable petrol to be carried in bulk in a ship.

The remaining tests relate to experiments carried out to determine the permeability of concrete, the means of protecting reinforced concrete from the corrosive action of salt water and from the disintegrating effect of vegetable lubricating oils on the interiors of the self-propelled vessels.

It was found that without any surface treatment 2-in. slabs of concrete, cast with their faces vertically, would frequently resist water pressure of 200 lb. per square inch. It was concluded that it was unnecessary to use any waterproofing compound, and that the richness of the concrete, together with the grading of the aggregate, were sufficient to guarantee watertightness.

Construction and Use of Nomograms

From The Times Engineering Supplement, London.

The methods now known as nomographic began to be developed by d'Ocagne in 1884, and of late years have been increasingly recognized and used in engineering practice. Even now, however, they cannot be said to be adopted generally, and much labor could be saved and insight gained if they were.

The construction and use of nomograms, though they are not matters of serious difficulty, often take a certain alertness to profit by the circumstances of the formula or equation to be represented, and some readiness in the "low cunning" of algebra. These cannot be described or exhibited satisfactorily without going into a good deal of detail, but without insisting on the individual devices employed in nomography a sketch of its purposes and an indication of the lines on which it works may be useful and opportune. The **locus classicus** for further information is d'Ocagne's "Traité de Nomographie," but those to whom the subject is new would perhaps be well advised to begin with the more concise exposition of Dr. S. Brodetsky ("A First Course in Nomography," Bell, $2.50 net), from which some of the following diagrams have been adapted.

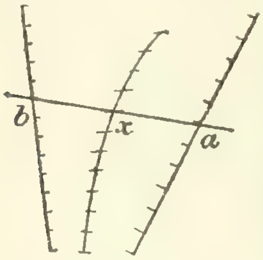

Fig. 1.

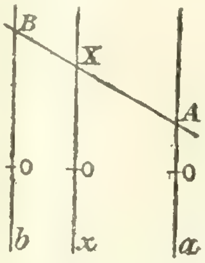

Fig. 2.

Graphs and Nomograms.—Both the nature and the purpose of nomograms are best understood when they are considered in context with ordinary graphs. A graph may, perhaps, be best regarded as a sort of template composed of points, which traces the path of a variable quantity with the change of other variables. The relation of the variables to each other may be merely occasional, like curves of disease or pauperism, and even though such curves may sometimes be compared usefully with curves representing the course of other phenomena, each set of phenomena is expressed completely by a single set of figures, and therefore by a single graph.

In engineering, as in other matters to which mathematical treatment is applied, the most fundamental and important sets of phenomena are not described completely by a single set of figures. Their relations are defined by laws, which are expressed in general equations or formulæ, and all that can be shown in a graph is one out of the infinite number of sets of values of the variables in question. If is desired to exhibit the path of the variable under consideration when the variables have other values than those used in the graph, as many sets of graphs must be plotted as there are comparisons required, and if they are too numerous other graphs must be interpolated without being plotted. The process is at best laborious, the interpolation difficult and not usually very accurate, and through its complexity the result often fails to give the compact view for which graphic methods are most sought.

The purpose of nomograms is to remedy these shortcomings of graphs, and, with a saving of labor, fewer lines, and an increase of accuracy, to present the desired view in a more legible diagram and to show more clearly and immediately the way in which changes in some variables affect the values of another. The method may, perhaps, be described best as substituting for the template or series of templates built up out of the points that represent single values of the variables a framework or scaffolding on which all the values can be arranged, the points representing one set of values of the variables lying on straight lines along the face of the framework, and their values being changed to another set by changing the position of the lines. The essential structure of the nomogram lies in the framework, and the straight lines laid along its face either can be drawn in for different values, or can literally be laid in the position corresponding to any set of values by shifting a transparent sheet having a straight line on its under side. What characterizes these straight lines in nomograms as developed up to now is that they cut the lines which constitute the framework in points representing simultaneous values of the variables in question, and on his framework the observer can pass immediately from one set of values to another merely by shifting one or a very few lines along its face.

The Commonest Method.—The type of a nomogram may thus be represented as in Fig. 1, in which the values of variables a, b, and x are so graduated by scales on the straight lines and curve that within the range of values for which the diagram is constructed corresponding values on each scale lie on the same straight line, and can thus be read off immediately by shifting the line a x b about the diagram. It is easy to imagine how readily, given a diagram of which the graduations had this property, one could shift the straight line about and read off all imaginable sets of collinear, and therefore simultaneous, values. What is not so easy is to imagine how to discover the framework and the graduations on which the movable straight line can give the required information. There is, indeed, no general method of invariable application; but the kind of construction that runs through most nomograms may be seen in the commonest class, which is built up of parallel straight lines.

The majority of expressions that are used in engineering mathematics can be reduced to adding, subtracting, multiplying, or dividing, including powers and roots under the last two heads; and by the use of logarithmic scales processes of multiplication, division, involution, and evolution can be derived from addition and subtraction. In substance, therefore, the commonest methods of construction nomograms are, or are derived from, methods of nomographic addition and subtraction. The nomograms by which quantities can be added or subtracted have little or no practical value in themselves. They can indeed, be constructed so as to serve for the solution of simple equations of one variable or simple simultaneous equations of two variables, but even for these purposes they usually are roundabout contrivances. Their importance lies in the fact that on them are based the constructions for nomograms by which the other operations can be performed; and to get a clear view of these constructions it is necessary to see how nomograms can be made for adding and subtracting.

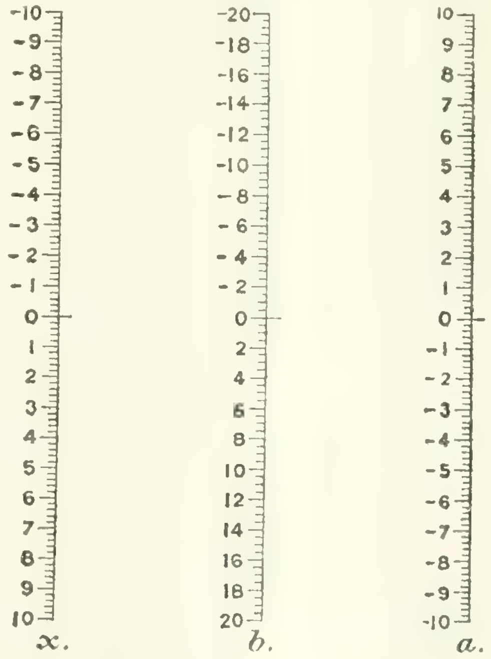

Fig. 3.

An Elementary Nomogram.—The frameworks of nomograms for addition and subtraction can be erected in various ways, but all of them depend on a simple and familiar property of similar triangles. The property can be cited and its application illustrated by imagining three vertical lines a x b, of which fixed points o o o are in a horizontal line (Fig. 2).

lengths measured from o along a [illegible] proportionate to values of one variable, along b to values of another variable, and along the intermediate line x to the sum of the two variables; and to enable these values to be expressed in figures the whole lengths of the lines, each measured from its o, are to be graduated uniformly into scales by units which are to be the same for a and b.

Now if these lines are cut by any line whatever AXB, the length OX will be intermediate between the lengths OA and OB; and the fundamental property of the elementary nomogram under construction is that which expresses the relation between those lengths. If x is mid-way between a and b, then $2OX = OA + OB$; if x is twice as far from a as from b, then $3OX = OA + 2OB$; and, generally, if the distances of x from a and b respectively are as m: 1, then $(1+m)OX = 1.OA + m.OB$.

This is the known geometry of Fig. 2; and from it follows the conclusion that if the number of graduations in OX is to be equal to the sum of the graduations in OA and OB, the graduations on x representing given values of the variable must be smaller than the graduations representing the same values on a or b by a multiple depending on the distance of x from a or b. The examples given show that this multiple will be smallest when x is mid-way between a and b, and the x unit graduation is accordingly half the length of the a or b unit graduation. Since the accuracy with which the results indicated by the scales can be read decreases as the unit graduation gets smaller, the nomogram is most serviceable when x is mid-way between a and b and its unit graduations are half the length of the unit graduations on a or b; and if x were so shifted in the figure, any line like AXB would cut off intercepts on a x b at such graduations that $x = a + b$, where the letter is used to denote the scale reading.

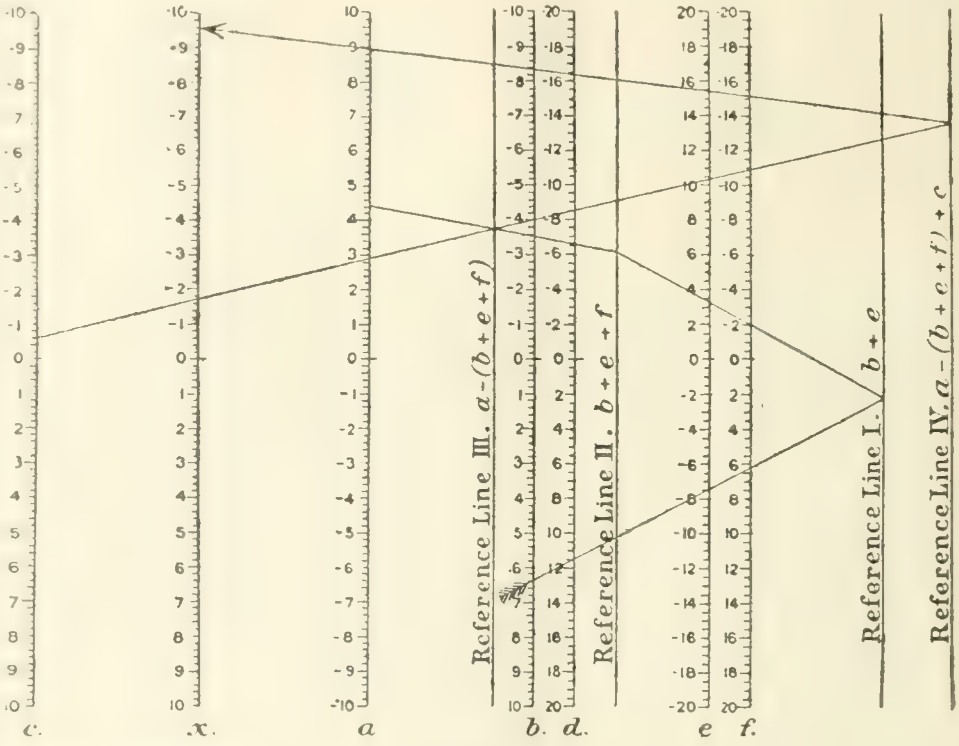

Fig. 4.

The sum of any two values of a and b can therefore be obtained by drawing a straight line to join the graduations on a and b that are marked with these values, and reading off the graduation of the point in which that line cuts x. Similarly, if the a divisions, instead of being twice as long as the x divisions, were made 2l times as long, and the b divisions, instead of being equal to the a divisions, were 2m times as long as the x divisions, the x intercept would represent the sum of l times the a intercept and m times the b intercept; i.e., the nomogram would represent the equation $x = la + mb$.

Finally a constant can be added to the sum of the two variable terms merely by slipping the a scale up along itself till its zero (o) stands above the horizontal level of the x zero by the length that corresponds to the value of the constant, or by doing the same with the b scale, or by slipping both scales up or down in such a way that the net upward shift of the a and b zeros relatively to the x zero corresponds to the value of the constant, and therefore adds it to the net reading of a+b which is conveyed by any line AB and read off at X.

Addition and Subtraction.—In practice it is obviously more convenient for the unit of the x scale to be as large as the a or the b scale. From Fig. 2 this can evidently be done by interchanging the positions and graduations of b and x, thus giving x the same graduation unit as a and b a unit of half that length. But with this transpoition b becomes the sum of a and x, and therefore x the difference of a and b. To reconvert x into the sum of a and b the scale of a must therefore be graduated in the opposite direction to the scales of b and x, graduations upwards from O being reckoned, for instance, positive in a and negative in b and x. Fig. 3 shows the nomogram so constructed. By its use any pairs of values of a and b can be added to or subtracted from each other in the manner indicated in the last paragraph, and generally similar reasoning to that used in discussing Fig. 2 will show that, subtraction being regarded as merely addition of a negative quantity, the reading $x = a + (-b)$ will be at a point on x collinear with points representing + a and − b.

Nomograms for more than two variables are constructed by dealing first with two and then adding or subtracting the others to the result one at a time, taking care not to use the same process of subtraction twice in succession, as this would reduce or increase the size of the final graduation inconveniently. Fig. 4 shows a nomogram for $x = a - b + c + d - e - f$., which may be written $x = a - (b + e + f) + c + d$. The steps in its construction are as follows:—Lines are taken for b with positive graduations downwards and for e with positive graduations half the size of those on b but upwards. From the preceding paragraph it is evident that a line on the other side of e and at the same distance from it as is b will represent b+e nomographically if it is graduated as b but in the opposite direction. As the value of b+e is only wanted as part of another total, it is not in fact graduated, but serves as what is called a reference or pivotal line on which the next part of the diagram is constructed. Another line in a convenient position is taken to represent f, and if this line is graduated with units half the size of those on b+e (or b), but with positive graduations downwards, a second reference line on the other side of f and at the same distance from it as b+e will represent b+e+f if it is conceived as graduated with the same units as b+e but with positive graduations downwards. A line in a convenient position is now taken to represent a, and a third reference line is drawn midway between it and the second reference line; if this third reference line is conceived as graduated with half-size units, positive readings upwards, it will represent a—(b+e+f). If equidistant lines be taken each side of the third reference line to represent c and a fourth reference line a—(b+e+f)+c, they will do so if the c line has full size graduations with positive readings downwards and the fourth reference line is conceived as having full-size graduations with positive readings upwards. If, finally, a line be taken to represent d with a half-size scale with positive graduations downwards, a line on the further side of d and at the same distance from d as is the fourth reference line will represent x if it is graduated with full size divisions, positive readings downwards. The transverse lines are shown on the figure to indicate how the additions and subtraction just described are carried out. The arrow feathers represent where these operations start and the head where they finish.

Multiplication, Powers, and Roots.—The above work is applied to multiplication, division, evolution, and involution by taking logarithms of the expressions in question, and plotting the sums and differences so obtained on logarithmic instead of ordinary scales. The readings of these scales when positive begin not in the middle but at the bottom of the scale, and when negative at the top; the interval 0 to 1 of an ordinary scale becomes 1 to 10 on the logarithmic scale, and when half-size units are used the logarithmic scale is just repeated, so covering 1 to 100, as on the scales of a slide rule. The decimal point in the result is put in by eye as on a slide rule, the diagram giving merely the working figures.

If therefore in the most beneral terms it is required to find the value $x = k a^{l} b^{m} c^{n} \ldots | f^{p} g^{q} \ldots$, where the indices are positive, though perhaps fractional, k is a constant, and the other quantities are variables plotted on logarithmic scales, it will be seen by taking logarithms on both sides that

$\log x = l \log a + m \log b + n \log c + \ldots - p \log f - q \log g \ldots + \log k$. Writing capital letters instead of logarithms, this expression becomes

$X = lA + m B + n C + \ldots - pF - qG \ldots + K$, and a nomogram for finding X can be constructed on the lines indicated in the last section. This nomogram, regraduated by converting each 0 to 1 interval into a 1 to 10 logarithmic scale, becomes the nomogram of the general product, and the value of x can be taken off it in exactly the same way as with additions or subtractions.

A large number of the expressions used by engineers in practice are of this form. The pressure on a plate against which air is moving normally ($R = 0.0194\ WSV_2$), the breaking load of an ash beam ($W = 675BD_2/L$), the wing area of an aeroplane ($A = 32W/CDV_2$), the maximum deflection of a beam ($M = 270WL_2/EBD_2$) are some examples of results of this sort can always be immediately found for any normal ranges if nomograms are once plotted for them. The method avoids a very large amount of labor and risk of error, in addition to being workable without requiring skilled computers.

Other Nomograms.—Nomograms can be constructed in a variety of ways for calculating other expressions. In a much-used type only the a and b scales are on parallel lines, and the x scale is on a curve. For quadratic equations, for instance, nomograms can be constructed in which the curve may be parts of a parabola or a hyperbola, a circle or a semicircle. By reducing a cubic equation to Cardan's form, in which the term involving the square is eliminated and only three terms are left, a nomogram can be constructed with two parallel scales and a plotted cubic parabola, and equations of higher order, when they happen to be reducible to three terms, can be treated similarly.

The scales again may be not parallel but intersecting. For the optical formula $1/f = 1/u + 1/v$ connecting the focal length of a lens with the distances of object and image measured on opposite sides of the lens two axes at right angles graduated uniformly with the same unit and the bisector o the angle graduated with a unit $\sqrt{2}$ times as great form a nomogram on which any three collinear graduations satisfy the above relation. If the axes were at an angle of 120 deg. all three scales would have the same unit. For adding three or more reciprocals conveniently reference lines may be used as with parallel scales.

Among other constructions one class of nomograms is to be noted as making and graduating its own x curve instead of selecting and graduating a line or form of curve from a knowledge of the constitution of a and b, as in the examples quoted above. If for instance, for two values of a, say a_0 and a_1, we know the values of b corresponding to a number of values of x, we can draw two sets of lines from the points a_0 and a respectively to the points on the b scale representing the values of b for the several values of x, and the intersections of corresponding a and b lines will be points and graduations on the x curve. This method is often convenient when plotting results that are obtained empirically without a definite knowledge of the actual functions by which a, b, and x are connected. It has in particular the advantage that by changing the a values it is possible to check the relation worked out from the first two values of a, as other values should give lines that pass through the same points on the x curve. The method may also save a considerable amount of labor.

In general, two facts must be borne in mind. The order of precision of the results to be obtained from nomograms is limited; and care must be taken to avoid applying the method in place of calculations in which a higher order of accuracy is required. The use of nomograms, again, is particularly easy even for untrained assistants; but their construction is often an opportunist business, demanding some mathematical facility.

Experiments in Street Paving with Rubber

From Municipal Engineering and The Sanitary Record, London, May 12, 1921.

Experiments in the use of rubber as a carriageway pavement have been made by the Rubber Growers' Association and Rubber Roadways, Ltd., in conjunction with the Borough of Southwark, extending over several years.

In August, 1913, a small section of rubber-capped hardwood blocks, between 2 and 3 yd. in area, was laid at the junction of Old Kent road and New Kent road. The rubber was in the form of a capping about ½-in. thick, having dovetail projections running longitudinally fitted into dovetailed grooves in a hardwood block. Shortly after these blocks were fixed several of the caps became detached and were replaced, but in June, 1915, it was decided to take up all the blocks for examination. During the year and nine months this patch of rubber had been under trial it had carried a traffic averaging over 190 tons per yard of street width per hour. No case of slip was found—a most important fact, as there was a belief that the rubber would prove to be slippery and not give a good foothold for horses, and that it would facilitate the skidding of vehicles. On being examined for wear the blocks placed side by side with unused blocks did not appear to have lost anything through wear, although there were several slight scratches on the surface, but on removing the rubber cap from the wood block it was found that considerable wear had taken place both on the wood and underside of the rubber cap.

At the latter end of 1918 a new type of block was produced consisting of a slab of rubber 9/16 in. thick, 9 in. long by 3 in. wide, vulcanized onto a steel plate, this plate being cut with eight cuts about 1 in. long so as to produce four lugs for holding down into the concrete.

A site was selected in Borough High street on the breast of the road on one side of the tramway, exclusive of the margins, and subject to fast, heavy traffic of about 240 tons per yard width per hour, about 100 yards in length, varying in width from 5 to 3 yd. This site had a foundation of reinforced concrete recently constructed for paving with wood blocks 4 in. deep. This depth of 4 in. was made up with fine concrete composed of clean grit sand in the proportion of one of cement to four of sand, in which the rubber blocks were placed in such a manner that the lugs were embedded in and gripped by the concrete.

This work was carried out in February and opened to traffic on March 16, 1920. Shortly after the traffic had been running over it several of the rubbers became detached from the steel plate and were replaced with new blocks having the vulcanite carried to a greater temper. Within a few months some 15 per cent of the blocks had been separated from the plates, and at this point it seemed settled that the type in use which had withstood satisfactory works tests would not succeed under the fast and heavy traffic. About half the area was then taken up and examination showed various weaknesses which must be eliminated, and also gave some surprising results of the behavior of rubber under the heavy conditions applied.

Further developments were made in the light of the experience gained, and a new type was produced in which the steel plate was substituted by a plate of expanded metal embedded in the vulcanite, this plate being provided with added lugs. With this latest type block the cleared area was relaid, the remaining portion patched, and the road reopened to traffic on Dec. 13th.

Since that date the section paved with the new rubber type has behaved very satisfactorily, and there can be no doubt this block is a decided improvement on the previous types.

Progress of British Government Housing Schemes.—During the week ending April 22 last bids were submitted for 1,045 houses, according to The Surveyor, London. Bids for 286 were approved bringing the total number of houses for which bids have been submitted to 191,175. Of this number bids for 176,793 have been approved and contracts signed for 159,084 houses.

The Failure of Metals Under Internal and Prolonged Uniform Stress*

BY DR. W. ROSENHAIN

[illegible]

The main subject of the present discussion is that phenomenon which has long been known by the distinctly inaccurate term "season cracking." The title has, however, been generalized into the form stated above, so as to allow of the inclusion of a number of more or less analogous occurrences which also call for discussion and investigation. Further, it has come to be recognized that failure under internal stress, which is generally the operating cause in what is known as season cracking, is strictly analogous in its nature to failure under the action of externally applied stress which has been operative for a very long time. It should, however, be clearly realized at the outset that prolonged stress in the sense in which the term is used in the present connection is something entirely different from alternating stress or repetition stresses such as are associated with the phenomena usually termed "fatigue." Although in the general sense of this word as used in ordinary language, failure under a prolonged steadily applied stress might also be described as fatigue, technical usage has limited the latter term to failure under alternating or repeated loading, and it is eminently desirable that we should not depart from that usage. The discussion of what is ordinarily known as fatigue, therefore, does not enter into the present subject.

Time Element in Testing Metals.—It is desirable to recognize at the outset that in the ordinary testing of metals, particularly under tension, the element of time enters only very slightly into the result. Numerous attempts have been made to discover whether even wide variations in the rate of loading produce any appreciable effect upon the tensile test results in ordinary metals at the ordinary temperature, and in every instance negative results have been obtained. Apart from such velocities as occur in the use of certain impact tests and the high velocities which arise in the use of projectiles, etc., it may be said that for the great majority of metals the results of tensile tests are independent of the rate at which loading is carried out. It came as a surprise to discover, as has been done in connection with the investigation of season cracking, that in certain materials and in certain conditions of those materials the apparent strength depends very largely upon the time during which the load is allowed to act. It will be seen later, and it is now fully recognized, that this time effect is definitely associated with a particular type of fracture. It is only in the production of intercrystalline fractures that such a time effect makes itself felt, and this is a fact of fundamental importance which must be taken into full account by any theory by which it is endeavored to explain the phenomena which we are here discussing.

From the practical point of view the discovery that a time effect in tensile loading may exist in certain conditions is a matter of very grave importance. It has been said in the course of discussion on this subject "that it is an axiom of engineering that a piece of metal which will bear a static load for a short time will bear the same load indefinitely, provided that the metal does not deteriorate as the result of corrosion or other external influences." It is further suggested that, since engineering structures as a whole are not frequently subject to serious failure, the above axiom is borne out by practical experience. Two considerations, however, must be borne in mind in this connection. In the first place, the material most widely employed in those engineering uses in which relatively important stresses have to be borne is steel, and it is evident that in this particular material the rate at which intercrystalline fracture can be produced by a constantly operative stress of sufficient magnitude is very slow indeed, particularly if certain accelerating causes which will be referred to below are absent, as appears to be the case in very many structures. In the second place, thanks to the large factor of safety generally employed in engineering design, where structures have to bear important working stresses, it is likely that the actual stresses continuously in operation on pieces of steel in large engineering works are below the [illegible]ble of [illegible] intercrystalline movement even in favorable conditions. From the practical point of view, therefore, it appears unlikely that we need fear in the future any large amount of failure of engineering structures from intercrystalline fracture resulting from the prolonged action of working stresses. None the less, a few cases of failure have occurred, both in roofs, bridges, and steam boilers, after many years of service, which suggest that in certain cases stresses are operative which are capable of producing such a result. It appears probable, however, that in all these cases the operative stress has not been the working stress of the part in question, but a system of internal stress resulting from some special mode of construction, such as very severe riveting, which may have been adopted in that particular case. Nevertheless, even in steel structures the possibility of fracture after a very long time from the continued effect of constantly operative stresses is one which should be carefully considered and taken into account, particularly where working stresses which are constant in their operation are calculated at relatively high values.

Nature and Origin of Internal Stress.—The view has already been indicated in the previous paragraph that intercrystalline fractures of the kind here under discussion are most frequently the result of internal stresses. This view is based upon the observation that such fractures are most frequently met with in cases where internal stresses are known to exist, and the amount of such internal stresses can in some instances be, at all events, approximately estimated. It has, however, recently been shown by Messrs. Moore, Beckinsale, and Mallinson[1] that precisely similar types of failure can be produced by the prolonged action of an externally applied stress, so that it would be erroneous to ascribe the phenomena exclusively to the effect of internal stress. This is of importance, because in certain views to be discussed below it has been suggested that cracking of this type can only occur as the result of unequal cold working or deformation. From what has just been said it would appear that the effect of such unequal deformation is an indirect one and produces the result by setting up severe internal stresses.

In view of their importance in connection with the present subject, the nature and mode of origin of internal stresses deserves some consideration. In the most general terms it may be said that internal stresses are the result of unequal changes of dimension in different parts of the same piece of metal. Such unequal changes of dimension may result either from mechanical or thermal causes. If, for instance, in the cold drawing of a metal rod the operation is conducted in such a manner that the external portions of the rod tend to undergo greater elongation than the internal portions, the extension of the external portion, seeking to draw with it the core, will place the latter under a tensile stress sufficient to bring about the necessary accommodation of length by elastic elongation. When the pull on the external portions of the rod is relaxed the internal portion will endeavor to contract and will set up a compression stress in the external parts. The result will be a piece of metal containing a system of internal stresses, tension in the interior, compression in the exterior, such that the sum of all the stresses is zero, as it necessarily must be in a piece of metal at rest and from external constraint. As has been shown by Heyn[2] in his May lecture to the Institute of Metals in 1914, the presence of these internal stresses can be recognized by gradually cutting away the outer portion of such a rod. When this is done the material in compression being cut away, the rod as a whole will contract, the tensile stress in the interior portion being thereby relieved. If, however, the rod is not cut, the stresses are continuously operative and in some cases lead to cracking of the rod by intercrystalline fracture after the lapse of a longer or shorter period of time.

Perhaps a simpler way of looking at the question of internal stress is to think of a flat strip of metal which initially is free from internal stresses of any kind. Such a strip can be bent into a U-shape and then, if the opposite ends of the U are clasped together by means of a clip or a spring, a definite tension is produced in that fastening. If instead of such a fastening being employed, the strip of metal is bent into a circular shape, with the two ends close to one another, there is still a tensile stress at the point of junction. A strip bent in this manner, however, is nothing more nor less than a short section of tube, and the precise manner in which it has been brought into that shape has very little effect upon the stresses present in it. It will be seen, therefore, that in any cold worked tube—that is to say, in any piece of metal which has been brought into a tube shape by deformation in the cold—there must be a circumferential tensile stress. One can look at the production of a cup or of such a form as a cartridge case in much the same manner by regarding it as being made up of a number of elementary strips bent up into the shape of a radial section of the cup in question. Instead of being kept in their bent shape by an external attachment, these are held in the case of a cup by being attached one to another all around the circular rim of the object. In this way we see that in a cup of this sort there must also be a considerable circumferential tension.

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[1] Moore, Beckinsale, and Mallinson. Journal of the Institute of Metals, 1921, 1.

Values of Tensions and Other Internal Stresses.—It is of considerable interest to ascertain, if possible, what values such tensions and other internal stresses may attain. It must be said at once that they cannot in any circumstances attain a value higher than the elastic limit of the material in the conditions in which it finds itself when the article is finished. This is obvious, because a stress higher than the elastic limit operating in this way would simply bring about further deformation of the material. On the other hand, it is not easy to ascertain precisely what is the elastic limit of the material in the condition in which it is present in the finished article in any given case. When a piece of metal is bent permanently, it is obvious that not only elastic deformation has taken place, but also a considerable amount of cold work or plastic deformation. This latter type of deformation, as is well known, results in a raising of the elastic limit beyond the value which it had in the unstrained material, and the extent to which this limit is raised must depend upon the severity of the cold work which has been done. An attempt has been made to calculate the intensity of the stresses remaining in a finished article, such as a spun cup of brass, by cutting the material up in various ways and measuring the extent to which the cut edges become separated when released. Unfortunately, the calculation of stresses in this way gives results which cannot be regarded as particularly reliable or accurate. The actual stress distribution is always complex, whereas calculations require assumptions based upon a simple stress distribution. Further, even when such a piece has been cut away from its surroundings and allowed to spring back, it is by no means free from internal stresses. In the case of a strip which has been bent and then released, the presence of residual internal stresses can be very readily shown. If the bending of the strip has been sufficiently severe in the first instance, it does not spring back to the straight position when released, but retains a very marked curvature. Now, it is clear that as the result of bending in this instance, portions of the metal near the interior and exterior surface have become plastically deformed, the former in compression, the latter in tension. Up to a certain point in the thickness of the section, however, the deformation has remained elastic, and it is this elastic deformation which leads to the springing back of the specimen when released from the bending force. That the springing back is incomplete, serves to show that the elastic forces at work in the interior have not been able to overcome the resistance of the previously plastically deformed metal near the two surfaces, with the result that in the strip apparently released from constraint we have a system of internal stresses balancing one another, leaving the exterior layers under compressive and tensile stress respectively. That this is really the case, can be demonstrated by removing the external layers of such a strip by some such means as dissolving them away in weak acid. The strip when treated in this manner definitely tends to straighten itself out, thus showing that the elastic forces at work in the interior are then able to bring about the further straightening effect, owing to the removal of the metal which had formerly resisted such straightening action. When, therefore, a previously bent strip is further bent by the application of external stress, or, as is the case in a spinning or a tube, is bent by the further application of deforming forces, it cannot be regarded as existing under the same distribution of stress as a flat unstressed strip of metal slightly bent within the elastic range. The calculation of stresses on the assumption of a uniform increase in tensile and compression stress respectively from the neutral axis of the section outwards, is accordingly incorrect, and this incorrectness may be very considerable in amount. It is therefore not surprising to find that materials whose tensile strength as ordinarily tested does not exceed 30 tons per square inch, may show internal stresses, calculated on the assumption named above, ranging up to 40 tons per square inch . It is suggested that such a result indicates merely that the formula employed is not applicable to the case under consideration.

Internal Stresses Fruitful Cause of Fracture.—While I believe that it must be recognized that the calculation of internal stresses, except in the simplest cases, such as that of a drawn rod, is a matter of much greater difficulty than might at first sight be supposed, there can be no question that internal stresses of very considerable magnitude exist in a great many pieces of metal, and that they are the most fruitful causes of fracture occurring after completion of manufacture, either after a short or possibly after a very long time. The fuller study of the whole question of internal stresses, their magnitude and the manner in which they are produced, and the means by which they can be avoided or subsequently eliminated, becomes a matter of first-rate importance, and one which has in the past been unduly neglected by those responsible for the working and using of metals. It has recently been shown by Moore and Beckinsale[3] that in the case of cartridge brass, low-temperature annealing—at temperatures from 200 deg. to 300 deg. Ce.—is capable of either removing internal stresses in brass, or, at all events, of relieving them to such an extent that they become innocuous. Some experiments recently made at the National Physical Laboratory entirely confirm this view, although the elimination of internal stresses is not as complete as might have been anticipated. At the same time, it is interesting to notice that even after this low-temperature annealing there does not appear to be any appreciable amount of recrystallization in the cold-worked material. This is of some theoretical importance in connection with one of the explanations of season cracking, which is dealt with below, but it is also of very considerable importance in this respect, that it raises the question as to the mechanism by which the metal is capable of adjusting itself to the existing internal stresses, without fracture and without internal rearrangement of an obvious kind.

The Phenomena of Cracking.—The phenomena of cracking resulting from prolonged exposure to internal stress have long been known in the case of brass, where they are unfortunately somewhat frequent in occurrence. Apart possibly from a few isolated observations in the copper-nickel-zinc alloy now known as nickel silver, the phenomena of season cracking in brass stood practically alone until in 1919 a paper on the subject was published by Rosenhain and Archbutt,[4] in which attention was called for the first time to analogous phenomena in other metals. These include a group of aluminium alloys, lead and steel. Since that time, analogous phenomena in still other metals have also been discovered. This constitutes an important step, and one which must be considered very carefully in connection with any explanation put forward for these phenomena. It is not sufficient now to put forward an explanation applicable to brass alone, since it is evident that a group of such similar phenomena in different metal must have a common explanation.

Before proceeding to consider the various explanations which have been put forward, it is desirable to state clearly the outstanding facts for which explanation is needed. The first typical feature of the phenomenon under discussion is that fracture occurs under a stress lower than that which is required to bring about fracture under an ordinary tensile test. That this is the case has been verified for a variety of materials subject to failure of this kind, and must now be regarded as indisputably determined facts. Moore, Beckinsale and Mallinson have shown that in the case of 70/30 brass, cracking will occur when the operative stress exceeds from 6 to 8 tons per square inch in a material whose ultimate strength under an ordinary tensile test exceeds 20 tons per square inch. In the case of an aluminium alloy having a tensile strength of 24 tons, Rosenhain and Archbutt have shown that cracking will occur under a prolonged load of 13 tons per square inch. In a paper contributed to the present general discussion, L. Archbutt shows analogous facts with regard to lead.

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[2] Heyn, Journal of the Institute of Metals, 1914, 1 (May Lecture).

The second typical feature, which is also common to the phenomenon in all the metals mentioned, is that fracture occurs with little or no plastic deformation, and that it is essentially intercrystalline in character. The fact that normal tensile fractures in the great majority of metals occur by the breaking across of the crystals is also to be regarded as well established; the same metal, when broken under lower stresses in the manner typical of the phenomenon now being discussed, exhibits an entirel different fracture.

Explanations of Spontaneous Cracking.—A number of ex[illegible] have been put forward to [illegible] for the apparently spontaneous cracking of brass, and more recently attempts have been made to offer explanations for the phenomena throughout the whole group of metals in which they occur. Any review of these explanations can, of course, be attempted at the present time only in the light of such knowledge as is now available. Probably none of those responsible for these various explanations would suggest that they are finally established, and that there is no need for further research. On the other hand, the elimination of obviously impossible explanations is a desirable clearing of the ground, while it is also necessary to remove certain misapprehensions which appear to exist. That a sound theoretical explanation of these phenomena is eminently desirable will scarcely need urging. The permanence and durability of all metals and of the structures and machines made of them is of such vital and fundamental importance that we are bound to seek for the fullest possible light on all phenomena which affect this matter. Even, therefore, if the theoretical explanations put forward may at times appear to be somewhat abstruse, yet those interested more immediately in the practical side of the question should not regard them as purely of academic interest. It is by the study of outstanding and peculiar phenomena which do not appear to be readily explained that new knowledge is obtained as regards the internal structure of metals and the mechanism by which they resist applied stresses. Any advance in our knowledge of that mechanism is a step forward towards presenting to the engineer materials of greater strength and durability than those at present available. If, therefore, the whole of the present general discussion were to be devoted to a consideration of theories explaining or purporting to explain the causes of intercrystalline fracture under prolonged stress, the time which may be devoted to it must be regarded as well spent.

Perhaps the simplest explanation which has yet been put forward to account for the failure of metals under prolonged stress is that which, although not explicitly given, is contained in a paper by Hatfield and Thirkell, published in 1919.[5] This may be called the "simple stress" theory, since it implies that the actual stress existing in brass articles which subsequenly undergo "spontaneous" cracking, is so high as to be practically equal to the normal breaking strength of the metal, and that it only requires a small amount of corrosion or of incidental damage to the surface of the article to bring about rupture. Support for this view is sought by attempts to determine the intensity of the internal stress existing in various spinnings and other objects known to be liable to undergo cracking. It has already been indicated above that the methods of calculating stress employed in these cases is not really satisfactory and tends to give figures much higher than the real intensities of stress existing in the material. Further, the recent work of Moore, Beckinsale and Mallinson has shown that even in brass stresses of a very much lower order than those suggested by Hatfield and Thirkell are sufficient to bring about fracture of the kind typical of the phenomena under discussion. The "simple stress" theory must, therefore, be ruled out entirely.

A second theory, of an entirely different kind, held a considerable amount of ground for some time past. This was based on the idea that spontaneous cracking subsequent to the completion of an article occurred only under the effect of severe cold work. According to this view, the cold-worked article contains a large amount of metal in the amorphous or hard condition. This is known to be unstable at the ordinary temperature, and it is suggested, according to the view in question, that a small amount of gradual re-crystallization takes place in this amorphous material. It is known that a change of volume occurs in the transition from crystalline to amorphous or vice versa, and it is therefore argued that if re-crystallization occurs there is a local diminution of volume with a considerable intensification of stress, leading to the initiation of a crack. The real difficulty which must be faced by this theory is that there is no microscopic evidence whatever forthcoming, even after prolonged and careful research to suggest that re-crystallization can or does occur in cold-worked brass, for example, at the ordinary temperature. Until such evidence can be obtained the view that re-crystallization plays any part in the cracking phenomena now under discussion must be regarded as an unsupported assumption. Further, it is difficult to see how re-crystallization of this kind will account for the intercrystalline character of the crack, which is so typical and fundamental a feature of the whole phenomenon. On the latter ground alone, it would seem that the re-crystallization theory must also be abandoned.

A third theory, which appears to have received wide credence, particularly in America, may be called a simple corrosion theory. This view has been carried so far that the phenomena, which are more widely known in England as "season cracking," are frequently referred to in America as "corrosion cracking." Recently, Moore, Beckinsale and Mallinson have shown pretty definitely that general corrosion does not facilitate cracking of the kind now under discussion; neither is it possible to account for the typical intercrystalline nature of the fracture by any theory of general corrosion, although it will be seen below that the theory of localized chemical action, quite distinct from general corrosion, put forward by Moore, Beckinsale and Mallinson is of very considerable importance.

Dispersion of Load in Stone and Brick Piers and Templates

From the Engineering Review, London.

Engineers who have had to design brick or stone piers to carry steelwork will often have been troubled as to how much may be allowed for dispersion of load. If, for instance, we are given that the safe pressure on brickwork is 5 tons per square inch, it is clear that this figure can be exceeded when the pressure is applied only on a comparatively short length of long wall.

This question was investigated experimentally many years ago by Bauschinger, but his figures are not commonly quoted in British books, so that some designers may find the figures useful if we give them here.

The blocks were sandstone blocks of depth h and beradth a and width b; they were loaded centrally on the top surface over a length z parallel to the breadth b, and were supported on the bottom surface. The following results were recorded, the dimensions being in cms. and kilos. per sq. cm. respectively:

				Ultimate strength	
h	a	b	z	Measured on large area.	Measured on small area.
6.00	6.46	6.02	6.03	653	653
[illegible]	[illegible]	[illegible]	2.5	232	926
9.85	10.01	10.01	2.0	188	943
9.82	10.02	10.03	1.5	156	1,044
9.84	9.99	9.95	1.0	120	1,193
[illegible]	[illegible]	10.02	.5	102	2,050

From this we may deduce the approximate rule that for a loaded length equal to one-tenth of the total length we may take twice the stress for the small area, and for a loaded length equal to one-twentieth of the total we may take three times the stress.

In no case should the base be less than the height if this rule is to be followed.

A Test for Lead Poisoning.—The usual test for erosion is made by placing a small strip of bright lead—say, 1 in. by 1½ in.—in a test tube and covering it with a measured quantity of the water to be examined. If erosive ability is present a milkiness near the surface of the strip becomes sooner or later perceptible and quickly diffuses throughout the liquid. Later it will be deposited as a white powder at the bottom of the test tube. The quantity of lead taken up in a given time can then be estimated by the ordinary laboratory methods. Should the water contain substances which inhibit erosive action, a bluish-white insoluble coating is formed on the bright strip and no cloudiness appears. Pure distilled water is commonly found to erode lead vigorously. —From Municipal Engineering, London.

[illegible]

[4] Rosenhain and Archbutt, "Proceedings," Royal Society, A., vol. [illegible]

[5] [illegible] and Thirkell, Journal, Institute of Metals, 1919, 11.

Laying Telephone Cable Tubes for a River Crossing by Thrust-Boring

From The Engineer, London, April 22, 1921.

In carrying out the scheme of running the cables from the new Broadway Telephone Exchange on the south side of Jupp Road, in Stratford, London, E., it was necessary to cross the Channel Sea River in some manner, and to form accommodation for nine cables, each roughly consisting of 800 pairs of wires. The Channel Sea River is a tidal tributary of the Lea, and comes under the control of the Lea Conservancy. The proposal was that, immediately on leaving the Exchange—a nine-way duct should be laid below the south footpath in Jupp Road to the barrier at the end. The cables were then to be taken over or under the Channel Sea River and under the permanent way of the Great Eastern Railway at the junction adjacent to Stratford main station on the Woolwich branch, the river at the point of crossing being 38 ft. wide.

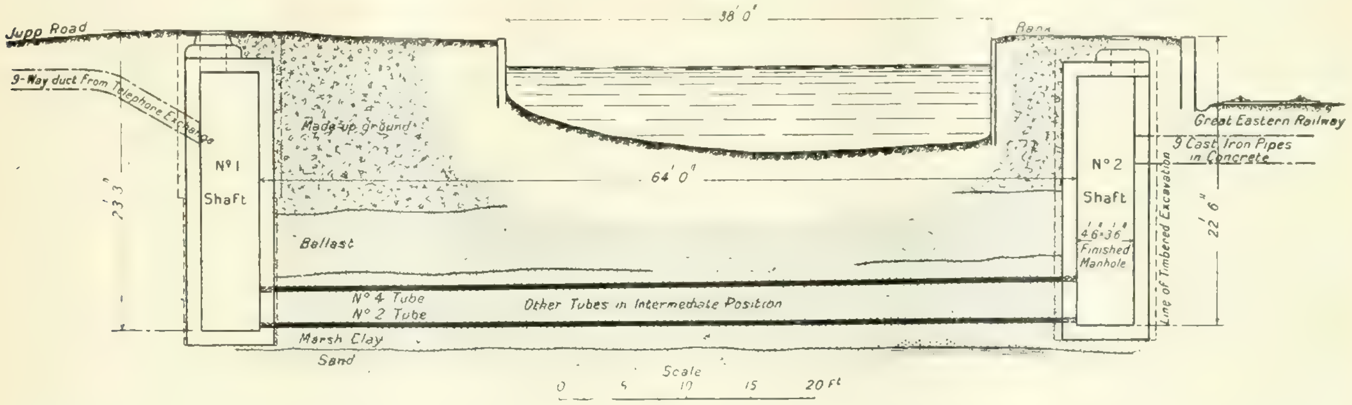

Fig. 1.—Cross Section Showing Location of Shafts and Tubes.

The following alternative schemes were considered for the river crossing:

(1) A reinforced concrete bridge carrying nine steel tubes.

(2) Damming the river in sections and burying the standard bitumen jointed nine-way duct at a depth of 6 ft. or 7 ft. below the river bed.

(3) Laying the nine steel tubes by the Mangnall-Irving thrust borer below the river, between shafts sunk one in Jupp Road and the other on the narrow bank between the river and the railway.

It was decided to make the crossing by the last-mentioned method, and the contract was undertaken by the Hydraulic Engineering Co., Ltd., of Chester and London, the sole licensees in England for the Magnall-Irving thrust borer, and the operations were carried out under the direction of Captain A. R. Mangnall.

An early form of the apparatus was fully described in The Engineer of April 9, 1920 [see Engineering and Contracting, June 30, 1920], and it is not now proposed to go into detail of the mechanism employed. The shafts were sunk in the position shown—No. 1 and No. 2 in Fig. 1. It had been anticipated that blue London clay would be encountered almost immediately. That, however, was found not to be the case. The first 14 ft. 6 in. proved to be made-up ground consisting of loam, sandy clay and stones, while the next 5 ft. were running sand and ballast. This seam of ballast was passed at 19 ft. in No. 1 shaft and 17 ft. in No. 2. Below it a blue-gray marsh clay continued for 5 ft. to 6 ft., and below the clay there was more wet yellow sand. It was originally intended that the borings should be made between 15 and 18 ft. down, but owing to the ballast it was decided to go deeper; the borings were actually carried out between the depths of 19 ft. and 23 ft. down, so that the ducts might all be in the seam of marsh clay just mentioned. It would, of course, have been possible to make the borings in the made-up ground above the ballast, but if that had been done there would not have been sufficient depth of overlying soil to give the clearance below the bed of the river specified by the authorities, so as to allow for future dredging and deepening. Both the vertical shafts were close timbered and heavily strutted, and owing to the presence of a considerable amount of water, particularly in No. 1, the Jupp Road shaft, pumps had to be kept going night and day during the operations. Beyond a 12-in. sewer near the surface and the rear face of No. 1 shaft, no obstacles were met with during the excavation.

The section of ground available for boring the nine holes and laying the cable tubes was approximately 4 ft. in depth by 3 ft. wide. Now, although it is a comparatively simple operation to make a single thrust-boring in that space, it is a difficult task to crowd together nine holes into so small an area. In thrust boring, the holes are made by the displacement and compression of the surrounding earth, there being no cutting action, and consequently no spoil. The effect is that any boring made closely adjacent to another tends to pull over to the boring previously completed. A special device to enable a number of bores—in this case three—to be made side by side and parallel to one another with only 2 in. of earth between each, was designed, and the nine tubes were to be laid in three horizontal tiers of three tubes each, being spaced vertically on 18-in. centers. The proposed sequence of operations were first to make the center boring and then to pass through the ground the device for forming two further bores, one on each side of the first bore. The first pilot boring was made successfully on March 22. The timbers were then drawn slightly to permit of the passage of the multiple hole-boring device. The poor character and water-logged state of the marsh clay was then fully apparent, as both faces collapsed and continued to break away and fall out through the aperture where the timbers had been raised, in a pulverized form like wet sand. The timbers were, accordingly, quickly driven back into position and the damaged faces packed as much as possible to prevent further collapse behind them, because the belt of running sand and ballast started to find its way through, and the river was in very close proximity at No. 2 shaft. In view of this failure, the idea of making the holes in series of three was abandoned, and each boring was made independently

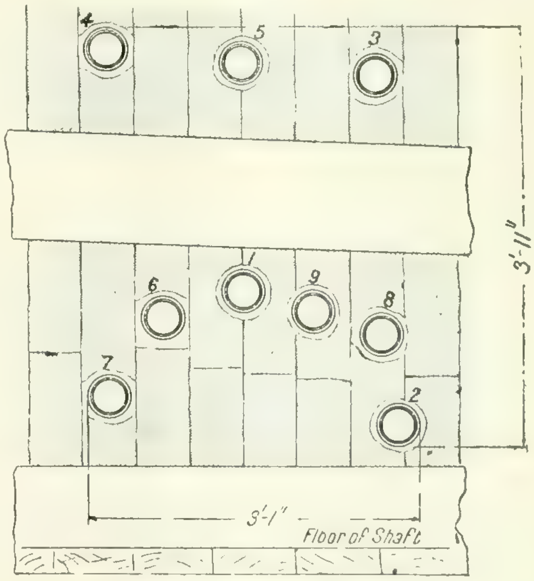

Fig. 2—Position of Tubes.

through 6-in. holes drilled in the timbers. The work by the [illegible] simple [illegible] prevented [illegible] not again disturbed. The actual positions of the bores as they were finally made in shaft No. 2 is shown in Fig. 2.

[illegible] were made [illegible] No. 1 shaft, the operation in each case being first to make a 4-in. diameter thrust boring, then to withdraw the boring tubes, then to increase by a second operation the 4-in. bore to 5½ in., and on withdrawing the larger boring tubes to attach the first cable tube to the end of the boring tube at No. 2 pit, so that all the cable tubes were pulled into the completed bore as the oring tubes were withdrawn to No. 1 pit. The load required to pull in the cable tubes was found to be very high owing to the collapsed ground at the faces being dragged into the bore by the tubes and causing excessive friction, and the ordinary maximum working pressure of 1 ton per square inch of the plant was exceeded. In view of this, the boring plant was transferred to No. 2 shaft, which, as it was slightly wider, permitted the cable tubes to be driven into the ground by a larger diameter boring cylinder, and the secondary operation of increasing the first ore from 4-in. to 5½-in. diameter was performed by driving the auxiliary pilot ahead of the cable tubes as the latter were being driven forward. The cable tubes were of 3½-in. internal diameter, and were in 6-ft. lengths and screw-coupled, the diameter over the coupling being 4¾ in. The nine tubes were laid at the rate of one per day. On completion of the laying of the tubes the two shafts were to be bricked up to form permanent manholes, having a concrete base and roof. Beyond the brickwork a band of puddled clay was to be formed as the timbers were withdrawn.

The successful carrying out of this undertaking forms a distinct advance upon all existing methods, and as the work was done under exceptionally difficult ground conditions, it suggests a very simple future application to those cases where reasonable ground strata is encountered. River crossings as great as 700 ft, to 900 ft. are being actively considered. The operation of thrust boring is limited to ground of a clay nature, although not necessarily pure clay; chalk, concrete, etc., cannot be thrust-bored.

Sewage Disposal from Main System of London

From The Surveyor, London, May 27, 1921.

The latest annual report of the London County Council, covering a period of five years from 1915-19, contains some interesting figures with regard to the disposal of sewage in the area of the London main drainage system. The area in question is approximately 149 sq. miles in extent, and the population in 1911 was 5,334,731. During the year 1919 the following quantities of sewage were disposed of:

Sewage Treated—	Mill. gals.
Northern outfall	62,713.7
Daily average	171.8
Southern outfall	42,633.3
Daily average	116.8
Sludge Sent to Sea—	Tons.
Northern outfall	1,227,000
Daily average	3,362
Southern outfall	769,000
Daily average	2,101
Sludge Vessels—	
Number of trips	1,996
Total distance traveled (miles)	220,012

The experimental treatment of sewage without chemical precipitants, which was commenced in the summer of 1911 and continued during the following summer, was transferred to the winter months of 1913-14 and 1914-15. In order to observe the effects the river was examined at first for the months of June, July, and August, 1913, and then in July, 1914. The examination has since been carried out continuously. It covers the whole waterway from Teddington to the Black Deep, where the sludge is deposited. The experiments showed that during the cooler and wetter periods of the year chemical precipitants might safely be discontinued. Owing to the war there was great difficulty in obtaining chemicals, and after October, 1916, no chemicals were used.

Wire Netting as Blasting Mat.—A correspondent states in a recent issue of the Quarry Managers Journal, that he has [illegible]ng blasting mats made of wire netting at one of his [illegible] by 2½ [illegible] of netting [illegible] by 4 in. mesh. Each piece weighs about 28 lb.

Measurement of Discharge of the Nile Through the Sluices of the Assuan Dam

By SIR MURDOCH MacDONALD and H. E. HURST.

Abstract of a paper read April 20, 1921, before the Institution of Civil Engineers.

After the completion of the Assuan Dam in 1902, measurements made in 1903-05 of the flow through the sluices showed that, for the same total area of sluice opening and the same head, the level produced at low stage in the river at Assuan, about three miles below the dam, varied from year to year, and that consequently no reliance could be placed on discharge curves based on values obtained in previous years.

Obviously the reason for this discrepancy was the varying nature of the bed level as sandbanks shifted and increased or diminished in size from year to year.

In 1905 a masonry tank with a capacity of 22,000 cu. m., was built below the dam to form a water cushion for the protection of the rock surface downstream. Advantage was taken of this to measure the volume discharging through one sluice into this tank and, from the information so obtained, to deduce sluice coefficients, which were found to be somewhat greater than previously estimated.

Questions having arisen as to the accuracy of the new figures by those interested in the older discharge tables, the senior author asked Mr. Hurst to check all the results obtained up to date. He had also had the entrance to one of the sluices remodeled so that a rectangular opening might be obtained, and coefficients for such a sluice deduced from the volumes of water passed into the tank. This was in the expectation that a comparison between the two sets of results—those for the particular bell-mouthed sluice adopted at Assuan, and those for a rectangular opening—would enable a closer approximation to be made for any given intermediate form of opening, and thus make the results obtained at Assuan of use elsewhere.

This paper is a résumé of what took place at the dam, together with the additional data gathered during Mr. Hurst's examination of the results. The method of sluice measurement of discharges is now believed to record the total volume of the summer Nile—January to July inclusive—correctly to about 1 per cent.

After describing the methods of measuring river discharges employed in Egypt, the authors point out that the measurements described in the paper are of interest because:

(a) They are the first in which the determination of volume by means of a tank has been applied to find the discharge of a large river.

(b) They attain an accuracy greater than that of any other known method.

(c) They are direct, and depend on no assumptions which may lead to systematic errors, thus forming a standard of comparison for other methods.

(d) They give information about the discharge of large sluices in other works.

The three steps in the method were:

(1) The direct measurement by means of a masonry tank of the quantity of water discharged by a particular type of sluice ("R. L. 100," i. e., having their sills at 100 m. above sea level) under different conditions.

(2) Experiments by which the discharges of other types of sluices, i. e., those at other levels, are compared with the discharge of an R. L. 100 sluice.

(3) The passage of the river through sluices whose discharges have been determined as above.

The paper then describes the carrying out of these three steps, and the necessary corrections and possibilities of systematic error are discussed.

The results from the tank measurements of the discharge through the R. L. 100 sluices showed that:

(a) For a given opening the coefficient of discharge increases as the head increases, until in the neighborhood of 10 m. head it becomes constant.

(b) For the small openings 1-5 and 2 m., there is not much difference between the coefficients for the same head, and the coefficients for both openings attain practically the same maximum value.

(c) For the small heads there is a progressive decrease of coefficient as the size of the opening increases. For heads greater than 3 m. this effect is reversed, and the coefficient increases with increase of sluice opening.

The next step was to find whether neighboring sluices interfere with each other when discharging, i. e., whether n similar sluices always discharge n times as much as one sluice. If there is interference, the effect produced would probably differ according as the discharging sluices were arranged in groups of adjacent sluices, or were separated by closed sluices.

This point has been investigated under different conditions of head, favorable weather always being chosen, but no effect due to variation in the arrangement of sluices has been detected.

Experiments were also made to determine the coefficients of discharge of other types of sluices of the dam, which differ in dimensions and in the levels of their sills. These results of these experiments are stated and discussed.

The discharges of four types of sluice have now been determined over the range of heads occurring during the low supply season. For the last few years, every day during this period the river has flowed through sluices whose discharges are known. The discharge of the river from January to July for 1916 and onwards is therefore known directly from the records of sluices open, and levels of the reservoir.

Curves constructed from float observations in 1901 and 1902, and from the mean of sluice discharges from 1910-1919 are of the same form, and approach each other closely at the higher discharges, the difference between the two being only about 2 per cent at a discharge of 1.500 cu. m. per second.

As already mentioned, the same level downstream of the dam does not always correspond to the same discharge; and the variations are considerable.

Such differences of this magnitude can only be produced by changes of river bed. By comparison of current-meter discharges and water levels, the same phenomenon is found to exist in varying degree at other places, being, for example, fairly large at Sennar on the Blue Nile, and small at Malakal on the White Nile. It is probably not very important at the higher stages of the river.

It is not to be attributed necessarily to changes near the gauge itself, as no doubt changes over long sections of the bed contribute to the change of level at the gauge for a given discharge.

Some experiments were also made with R. L. 100 sluices in which the bell-mouth was removed in successive steps. First of all the rounded lintel was made flat, so that the top and bottom of the sluice were parallel, and only the sides opened out at the mouth. Secondly, one side was made straight, and thirdly, the remaining side was straightened, leaving the entrance rectangular and the sluice of the same section at the entrance and throughout the tunnel.

Comparisons of discharge measurements by sluices and current meters show that for moderate river velocities no reduction is required on the discharges given by current meters when used under proper conditions. Mr. A. D. Butcher, at the Delta Barrage, has found only slight differences of the order 5 per cent between discharges measured in very turbulent water just below the head regulators in the canals and discharges measured in steadily flowing water about 1 km. downstream of the regulators at the regular discharge sites. Mr. B. H. Wade repeated these experiments at the Barrage, and found rather larger differences.

At Assuan, near the outfall of the sluices, in water so turbulent that a boat was in danger of being swamped, so that the discharge measurement was carried out from a platform suspended from a cable, discharges up to 17 per cent greater than the true value as given by the sluices were determined by Mr. Wade and Mr. Herbert by means of a current meter. The practical conclusions arrived at up to the present are:

(1) American experience tends to show that at very low velocities, in disturbed waters, Gurley current meters give results which are too low.

(2) At moderate velocities, such as those obtained at Assuan, with discharges at 2,000 cu. m. per second and less, there is no appreciable turbulence effect on Gurley current meters.

(3) In excessively turbulent water Gurley current meters record up to 17 per cent in excess of the actual discharge.

(4) Later experiments show that in the Nile, current meters, when properly used on well-chosen sites, are not liable to errors of any importance from turbulence at any stage of the river.

The Handling of Permanent Way Materials

By CECIL J. ALLEN.

From The Railway Engineer, London, January, 1921.

No inconsiderable proportion of the cost of permanent way maintenance is attributable to the labor involved in handling the material. For example, a modern 95-lb. or 100-lb. bullhead rail, of the 45-ft. length standard on most railways weighs approximately two-thirds of a ton, so that, in cases where it must be handled manually, not less than 14 or 16 men are required to lift it. Some companies do all their rail handling by means of cranes, running the rails out from the depots on to the job by a material train which has a permanent crane equipment. Other railways are not so well provided and the present expense of such equipment on a large scale is prohibitive. In any event, there are large numbers of instances, especially in the smaller permanent way material depots, where rails must be handled manually, for want of mechanical assistance. The same applies to made-up switches and crossings, which are still more awkward to manipulate.

Rolling Mill Methods.—In the handling of rails valuable lessons may be learned from the methods obtaining where rails are dealt with in the largest quantities, i. e., the rolling mills where they are produced. From the mill, after straightening and drilling, the rails are run out on live rollers to the rail-bank where inspection takes place, being stacked on the benches in a manner generally similar to the stacking in an ordinary permanent way depot, although the numbers of tiers per bench in the latter case seldom exceeds two or three. There is, however, this difference, that, whereas the cross-bearers between the tiers of rails in the vast majority of railway depots are formed by ordinary rails, at a steelworks they are always thin strips of steel, of approximately 1½ in. by ⅜ in. section. There is no comparison between the relative ease of manipulation of the two types of bearer; the strips may be adjusted in position in a moment or two, but the turning of the full-length rails to a right-angle on the bench manually is a laborious operation; the strips, again, may be cut to any length, whereas stacks of rails with, say, 45-ft. rails as cross-bearers must be limited in length to 45 ft., unless the cross-bearers overlap, in which event the arrangement of heavy rails for this purpose becomes more laborious still. Lastly, while a rail laid on its side as a cross-bearer occupies 2¾ in. of vertical space, a strip occupies only ⅜ in., and the height above the bench of the top tier of rails on a seven-tier stack is therefore 14¼ in. more in the former case than in the latter, the respective aggregate thicknesses of bearers being 16½ and 2¼ in. This is no small consideration from the manual handling point of view, when the available space for stacking is limited.

Loading Rails at the Rolling Mill.—The next question is that of loading from the stacks into the cars. In the most modern rolling mill plants this is done by means of magnet cranes traveling on overhead gantries—a method hardly possible of improvement—but assistance of this character is obviously out of the question in a small railway material depot. At steelworks where the loading is still performed manually, in order that the rails shall in no case be loaded "uphill," the loading-out roads are sunk sufficiently to bring the top of the bolsters on the cars down to a level with the rail-benches. All the movement of the rails in loading is therefore carried out on the level or downhill (from the upper tiers of the stack), but never against the pull of gravity. Consequently the maximum number of men essential in the loading up of, say, 45-ft. 95-lb. rails is six-two at each end of the rails on the bench (on well-greased slides one at each end is really sufficient, but the movement of such long rails in bulk by two men is rather heavy work), and one at each end of the car or cars. Steelworks loading, of course, requires to be carried out so rapidly, in order to keep the benches clear and prevent a stoppage of the mill, that considerably larger gangs than this are actually used in the loading of the rails. One minor essential in this operation is the constant greasing of the slides, boys being employed for this purpose exclusively when loading is being carried on. For maximum ease of handling, the rail-benches are kept, on the average, at a minimum of 2 ft. above ground level, rail level in the loading-out cuttings being a little over 3 ft. below ground, to make up the average 5 ft. 2 in. height of the wagon floors above rail

A Suggested Design of Rail-bank for Depots.—In the smaller railway material depots, where there is no mechanical assistance available for loading and unloading, the help of gravity should be invoked in the greatest possible degree. In the handling of rails this may be done in the simplest way by the provision of both "loading-in" and "loading-out" roads to the rail-stacks. The loading-in road should be at ground level, or slightly below, say, 6 in.; the rail level in the loading-out road should be about 3 ft. below ground level; and the level of the rail-benches should be some 2 ft. above ground. On the arrival of the rails from the rolling mill at the loading-in road in the depot, they are skidded down on to the benches, and when about the seventh tier is reached (the maximum height for convenient handling) the rails are running on the level from wagon to stack. When the time comes for loading-out, the higher tiers are run downwards from the stack to cars in the loading-out road, and when the bottom tier is reached, it is run on the level from the bench to the wagons. The movement of the rails is, therefore, exclusively on the level or downhill, gravity being almost always a help, and never a hindrance, in the operation. There should be a difference in level between the loading-in and loading-out roads equal to the maximum height of rail-stack contemplated.

Handling Methods at Existing Railway Depots.—It is surprising, however, to notice in how little degree this principle is in operation in railway permanent way material yards today. In the great majority of instances the rails are stacked practically on ground level, and loading-in and loading-out are conducted from the same siding, also at ground level. Loading-in is not a difficult operation, but loading-out by hand is most laborious, every rail, weighing in the case of 45-ft. rails some two-thirds of a ton, having to be run up the skids through a vertical height of from 1 ft. or 2 ft. to a maximum of as much as 5 ft. For this work a gang of fully 14 to 16 men is required, as against a total of six with the simple lay-out of rail-bank described in the last paragraph. The latter offers a saving of from 50 to 75 per cent on the cost of rail-handling at depots by the former method, against which has to be set the interest on the increased cost of providing the sunk loading-out road, which is by comparison a much smaller amount. If a portable steam crane be employed, a gang of six men will still be required—two on cars, two at the rail-stack to open out the rails, one to sling the rails, and one to drive the crane. The higher wage of the last-mentioned increases the wage per hour of the gang as compared with a gang of six loaders without crane assistance. To this must be added the interest on capital cost, fuel, maintenance and depreciation of the crane itself, as against the interest on the extra cost of constructing the rail-bank with a sunk loading-out road and of maintaining the latter—again probably adverse to the crane, unless the crane be profitably employed on other duties when not engaged on the rail-bank. In the matter of time occupied in loading, the disadvantage would probably lie with the crane, as, if the latter were using the same siding as the cars, shunting would be necessary every time a "set" had been loaded. There is, therefore, a strong case in favor of a separate loading-out road to a rail-bank, at a lower level than the loading-in road and at the opposite end of the rail-benches.

Handling of Switches and Crossings.—Still more difficult to handle than rails in permanent way depots are made-up switches and crossings, the former in particular being generally most unwieldy objects. Here again the sunk road is of the greatest value, in order to avoid loading up from ground level into the cars. In this case it is better to load-in, as well as load-out, from sunk roads, as switch and crossing material is seldom stacked to any great height, if stacking can be avoided, and it is thus possible to run the switches and crossings on the level between cars and storage benches. Similarly with chairs, fishplates, etc., labor in handling at depots is greatly reduced when the floor of the wagons used in loading-in or loading-out is on the same level as the stacking ground, as otherwise the force of gravity is always working against the loaders when loading up material out of the depot, rather than in their favor.

British Experiences with the Activated Sludge Process*

By H. C. H. SHENTON.

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Methods of sewage disposal in the past were developed by trial and error. The scientist eventually worked on this basis, but it cannot be said that he invented. The septic tank was developed from the cesspit; the various filters had their origin in the obvious method of straining sewage through ashes; and the purifying qualities of the earth were appreciated ages before the scientist came forward to explain the matter. It cannot be said that the scientist preceded the practical worker in the discovery of these methods.

The same cannot be said with regard to the latest and perhaps most important development in sewage disposal—viz., the activated sludge process. In this case the new method is the direct result of very careful research work on the part of the scientist. The causes of purification had been carefully studied; the fact that it was possible to breed the micro-organism required for purification had been proved. It was known that the purification effected by a filter was due to their presence, and it was argued that if the micro-organisms were present in sufficient quantities in the sewage they could purify it without the filter. Experiments proved that if certain algal growths were encouraged these would purify liquid sewage in the presence of air, and finally Dr. Fowler solved the problem by discovering that the sludge of sewage could be treated in such a manner that it would become the home of the micro-organisms required for purification, and that, if sludge were so prepared, the effect of mixing it with sewage in the presence of air would be exactly the same as that of filtration.

Hence it became possible to treat sewage and sludge at one operation in a tank and to produce any required degree of purification, without any filter, chemicals or other treatment. The work has been done during the last seven years, and the results are so important that it is desirable to give the matter very full consideration. A record of the preliminary work is desirable, and a careful study of the causes of the results obtained. Without this knowledge the chances of error are great. Owing to the rapid success of Dr. Fowler's method erroneous impressions have arisen, such as that this is only a partial treatment comparable to the Travis or Imhoff tank treatment; that the result is produced mainly by the agitation of the sewage and sludge, that aëration is of secondary importance, and so forth. The fact should be grasped at the outset that the micro-organisms required for the purification of the sewage can only be produced by aëration, and that the agitation of the sewage is only required in order that the microbes may be thoroughly mixed with it in the presence of air. For the rest, the matter is one of economical working and good engineering. The better the enginering work, the cheaper the process will be. The stage where the scientist required the assistance of the engineer was for once fully appreciated, and the rapid evolution of the system followed.

Earlier Experiments Leading Up to Activated Sludge Process.—It is entirely incorrect to imagine that the activated sludge process is merely a method of purifying sewage by means of aëration. It may appear to the casual observer at the first glance that he sees in the activated sludge process the perfection of a method which has been tried many times for years past of purifying sewage merely by blowing air through it; but it is much more than this.

It will be remembered that in the year 1892 Adeney attempted to purify sewage by aëration; Duprez and Dibdin tried the same experiment on the London sewage. A patent was graned in 1886 to Hartland for the same purpose. In 1897 Dr. Fowler tried the effect of aëration on the effluent obtained after chemical precipitation. In the same year Dibdin read before the Institution of Civil Engineers a paper in which he pointed out that the purification of sewage depended in micro-organisms, and here probably we have the first example of the correct understanding of the problem. In 1902 Dunbar showed that the purification of sewage was affected by slime which collected on the filter bed. Dr. Calvert, in a paper read before the Association of Managers of Sewage Disposal Works, said that in 1908 Dr. Wilson was led to suspect that perhaps the slime on the filtering material contained a clotting enzyme which could clot the colloidal matter in fresh sewage just as rennet clots the casein in milk. At that date some of the coating scraped from the filter medium was shaken with fresh sewage and did produce a certain amount of purification, but air was not blown through the sewage. Dr. Fowler acknowledges that this idea of a clotting enzyme was one of the features contributing to the elaboration of the new process. Black and Phelps found that, under certain conditions, aëration did purify the sewage to some extent, and were so sure of their work as to recommend that a portion of the sewage which was discharged into the harbor at Newport should be purified in this way. Clark and Gage found that, when sewage was aërated for 24 hours, both the free ammonia and the albuminoid ammonia were reduced to some extent, but that, in the presence of certain algæ, not only was the albuminoid ammonia still further reduced, but also that nitrification took place.

The Lawrence, Mass., Experiments.—Clark, in a paper published in 1916, said that what was now known as treatment of sewage by the activated sludge process had been in operation at the Lawrence Experiment Station of the State Department of Health of Massachusetts since early in 1912. During a series of experiments made at the station in 1911 it was found that the presence of certain algal growths in bottles of weak sewage caused purification of this sewage. This happened even in sealed bottles with the liberation of oxygen. It was found also that these growths, aided by forced aëration, effected remarkable purification.

Immediately following this work in the spring of 1912 extensive experiments were begun with regard to what could be accomplished in the actual purification of sewage by aëration aided by growths. For several months this work was carried on in gallon bottles or carboys, and it was found that by 24 hours' aëration of sewage containing growths of various kinds an effluent could be obtained which was stable, with nitrates at times equal to fifteen parts per million and containing only 33 per cent. as much organic matter as the untreated sewage. A shorter period of aëration gave clarification and stability, but nitrates were not formed. The sewage was emptied from the bottles daily, only the growths and sewage slime being left. This work was shown to Dr. Gilbert Fowler, of Manchester, in the autumn of 1912. On his return to England he and his colleagues, Ardern and Lockett, began similar work, and when Ardern and Lockett's paper was published in 1914 Dr. Fowler stated that it was only right to admit that the work was really due to a visit to the experimental station at Lawrence, where he had seen sewage which had been considerably purified by 24 hours' aëration.

Dr. Gilbert Fowler's Studies at Manchester.—In the paper by Ardern and Lockett the authors state that after Dr. Fowler's return from America he described to them a laboratoy experiment which he had seen at Lawrence on the aëration of sewage in the presence of green organisms, the bottle in which the sewage was aërated being coated inside with strands of algal growth. Dr. Fowler suggested that new work might with advantage be carried out on somewhat similar lines. The essential difference between the Clark, Gage and Adams' experiments and those of Dr. Fowler and his colleagues is that the American workers had fixed surfaces for supporting the active bacteria, whereas Dr. Fowler retained the sludge to form the nidus for the bacteria. Thus the agitation and diffusion of activated sludge throughout the whole of the liquid in open tanks, the essence of the activated sludge process as evolved by the English workers, was new.

The preliminary work at Manchester was carried out in bottles each having a capacity of 80 oz., and in the case of the first experiment five weeks' continual aëration was necessary to obtain complete nitrification. At the end of this period the clarified liquid was separated by decantation and a further dose of sewage was added. This process was repeated a number of times, the solids which were deposited being always retained. It was found that when sewage was aërated in the presence of this activated sludge, as it has been termed, the sludge being present in proportion of about 20 per cent., a stable effluent which contains nitrates could be produced by from six to nine hours' aëration.

These laboratory experiments were followed by others on a larger scale, one set being carried out on the continuous system and the other set of experiments on the fill and draw system. For the fill and draw experiments casks holding 50 gals. were used in the bottom of which a porous tile was fixed and through which air was blown into the sewage. This porous tile is a patented article. The results of these experiments showed that with six hours' aëration, the four hours' oxygen figure was reduced from 10.9 to 1.10, showing a purification of 90 per cent. In a further paper Dr. Ardern described the results obtained with a larger plant capable of dealing with 45,000 gals. a day, a period of aëration being from 4 to 6 hours. Purification of 85 per cent. was effected on the oxygen absorbed figure and nitrification took place. This plant was operated on the fill and draw principle.

Messrs. Kinnicutt, Winslow and Pratt, the well known American authorities, make the following statement in their book:—"It was the Manchester studies, and particularly the discovery of the effectiveness of previously aërated or activated sludge in promoting oxidation, which really gave us this important method of sewage purification. . . . American engineers should reciprocate Dr. Fowler's graceful acknowledgment by recognizing that none of the investigations on this side of the water had really brought sewage aëration to a state of practical usefulness. We may therefore claim that the activated sludge system is an English invention and is not, as some have thought, an American process.

The First Large Scale Experiment in England.—The first large scale experiment in this country was carried out at Salford, near Manchester, in 1914-1915, in existing tanks which had been fitted with a form of aëration apparatus designed for a different purpose, but it was found to be capable of easy adaptation to the new process. One of these tanks was worked on the fill and draw system, and later on a section of the same tank was worked as a continuous flow tank. The results obtained were satisfactory, and were described in papers written by Melling and Duckworth at the time. It was evident from this experiment that sewage could be highly purified on a large scale by the new method, but trouble was experienced from choking of the jets which were not suitable for the work, and this resulted in uneconomical working. It was at this stage that a private firm, who had been carrying out experiments since 1913 in collaboration with Dr. Fowler, entered into contracts to treat sewage on a large scale. It will be observed that, although Dr. Fowler saw the activated sludge process was essentially a problem for the bio-chemist, and that the development of the process in the experimental stage must be chiefly the work of the chemist; he also recognized the fact that the application of the process, the design of the apparatus, the decision as to methods of working, and of the most suitable forms of tanks were distinctly the work not of the chemist, but of the engineer. It was evident to him that unless this system could be made to work economically it would be practically useless, and it was equally evident that this economical working could only be ensured by the best engineering work.

Thus it came about that Dr. Fowler put the matter into the hands of engineers, and that the best methods of aëration were applied. The engineers, seeing the great possibiilties of the method, were ready to carry out and pay for the further research work required. They entered into contracts in 1916 to treat large quantities of sewage at Stamford and at Worcester, and to produce a suitable effluent which would not carry more than four parts of suspended matter per 100,000 parts, and to do this work economically. They gave a guarantee that they would do all this work including the reinstatement of the old works in case of failure. This was a very serious undertaking, seeing that 100,000 gals. of strong sewage were treated per day at Stamford, and 750,000 gals. of sewage of average strength were treated per day at Worcester. The satisfactory working of these plants is a matter of common knowledge.

Activated Sludge Process Installation in England and America.—The process was very quickly adopted in consequence at a large number of places in England and America, and during the war plants were installed by the Ministry of Munitions, by the United States Red Cross, by the Admiralty and others. In this country plants were installed at Baguley, Davyhulme (Lancashire), Worcester, Stamford, Aintree, Blackpole (Worcestershire), Withington, St. Albans, Tunstall, Moreton (Dorsetshire), Harpenden, Witney (Blanket Co.), Oxfordshire, Birmingham, also abroad by the British engineers at Jamshedpur (India), Holte (Denmark), Burmeister (Denmark), Sibpur (India), Kimberley (South Africa). In America various plants were installed on the [illegible] principle, notably [illegible] at which place extensive experiments were carried out resulting in the decision of the authorities to spend £1,000,000 upon the new system, and at Houston, Texas.

Experimental tanks were also installed at Sheffield depending upon mechanical agitation, in which the oxygen is taken into the sewage direct from the atmosphere at the surface of the tanks.

Perhaps the most notable fact with regard to the activated sludge system, and one which will probably have far-reaching effects, is the approval given by the Ministry of Health, who sanctioned a loan in the case of the Reading Corporation for works required to treat the whole of the sewage amounting to 2,750,000 gal. per day by the system. It is clear then that we have before us a new method of sewage disposal which is of extreme importance and which is deserving of the most careful study.

Importance of Aëration.—It will be understood that the line of investigation suggested by Dr. Fowler was really the intensification of stream purification. It had already been grasped that a stream polluted with sewage will clarify itself in the course of its flow. Dr. Fowler pointed out that the agitation caused by the flow in a stream keeps all the light matters in suspension, and also that the water in the stream is aërated by contact with the air at its surface. In order to try to produce these conditions in an intensified form—viz., aëration and agitation, the first idea was to have a series of air lifts which would give very great agitation combined with the most intimate contact of air with the sewage. In order to obtain the greatest amount of surface in contact between the air and the liquid it was decided to atomize the air. A simple calculation will show that in order to obtain the maximum superficial area of contact between air and water the air must be split up to fine bubbles. For instance, a cubic foot of air split up into ⅛-in. diameter bubbles gives 1¾ million bubbles, and their aggregate superficial area is roughly 600 ft. This area increases inversely as the diameter of the bubbles, so that the aggregate area of 1-16-in. diameter bubbles produced from the same quantity of air would be 1,200 sq. ft.

It was thus realized that diffusers arranged on the bottom of the tanks without baffles or rising pipes would give a greater circulation per unit volume of air than the ordinary air-lift pump arrangement. The circulation of water in water is practically frictionless, while the friction of water in a pipe is considerable. Consequently the volume of air required to move the water would be very much greater in the case of the air lift than in the case of the diffuser arranged on the tank bottom. The diffuser is in effect an air-lift pump without pipes. Its object is to agitate and move the water in the direction required, and to aërate it at the same time. Many calculations were made and considerable thought was given to the problem of producing the required agitation and aëration of the sewage. Aëration by means of mechanical agitators was tried, and motor-driven paddles were used for impelling the sewage in the tanks, but after considerable trial it appeared that there were so many disadvantages in connection with the mechanical agitation method that it was clearly uneconomical.

Comparison of Diffused Air and Mechanical Agitation Methods of Aëration.—A comparison of the diffused air and mechanical agitation methods of aëration gave the following results:

(1) The air compressor required in the diffused air method can be driven direct by a prime mover, and only one conversion of energy is required, as the compressed air creates circulation of the sewage by direct displacement. In the case of mechanical agitation a machine is required in each tank of the series, and many agitators are required in each unit. These need electric or other motors, and thus not only is the prime mover required, but also an electric generator, sets of motors and speed-reducing gear, and, lastly, sets of agitators in the tanks. Four conversions of energy are needed as against one for the diffused air method.

(2) With regard to the number of machines required, one prime mover and one air compressor giving a variable volume of air will operate the whole plant, both for aëration and return of sludge, and thus only two machines are needed. With mechanical agitation a much larger prime mover will obviously be required to generate electricity for several motor-driven agitators and for motor-driven pumps for returning the sludge. Assuming a dry-weather flow of 10,000,000 gal. a day, the number of moving mechanisms required in operation would probably be about fifty in the case of mechanical agitation, as against two for the diffused air method.

(3) With regard to the means of transmission of the energy, in the case of diffused air large cast-iron air pipes are used. These give storage and cause no greater losses than occur in the case of electric transmission, and they will, moreover, last a life-time if properly coated. In the case of mechanical agitation electric leads are required. These give no storage, the insulation is liable to perish, and naked wires will corrode. Anyone who has used electric leads in connection with sewage tanks will know that serious trouble is likely to occur. Motors, however well protected, are not likely to have long life when close to sewage tanks. Lead-coated cables have been reduced to powder through the gases rising from the sewage.

(4) The comparison with regard to supervision and attendance is equally clear. In the case of diffused air, all running machinery is concentrated in one central building, and thus superintendence will be reduced to a minimum, attendants will be few in number, and they will be under shelter at all times. In the case of mechanical agitation many motors will be required, each having its own switch and fuses, making many small buildings necesssary. A considerable number of attendants and constant supervision will be required. The pumps and agitators work, either in the open air or in sewage, under all weather conditions. This means that the trouble is much greater, and that there is a greater likelihood of neglect.

(5) Diffusers have a long life. The Worcester and Withington diffusers have been in operation for 4½ and 3½ years respectively, worked day and night, and no renewals have been required as yet. On the other hand, the average life of the working parts of machinery, such as is required for mechanical agitation, would be about five years, and the renewal of contacts of switches, fuses and brush gear of motors and generators would be a matter of frequent occurrence.

(6) A still more important matter is the necessary duplication of machinery. In the one case all that is needed is to have a duplicate air compressor. There is nothing in the tanks which can break down without warning; 10 per cent or even a greater proportion of the diffusers can be replaced without stopping the flow and without any considerable effect on the effluent. On the other hand, it would be impossible to duplicate the mechanical agitation machinery except at enormous cost and with extraordinary complication.

(7) In an agitator ceases to work owing to some minor trouble, such as is of frequent occurrence in electrical machinery working day and night, the sewage will pass through that tank of the series untreated. This must affect the whole effluent and the activated sludge in this unit, even after the unit is isolated, will become deactivated and the sludge will have to be retreated before the tank is again put into use or else the tank must be cleaned out. As stated above, there is no such possibility of trouble in the case of the diffused air method.

(8) The lubrication oil used in the case of the air compressor plant under cover must be very small when compared with that required for lubricating a much larger quantity of machinery working under the worst conditions of varying temperature in the open.

(9) In the diffused air method the compressed air is used for the return sludge lifts, but with the mechanical agitation plant, if centrifugal pumps are used they will tend to disintegrate sludge and make it difficult to settle. Hence compressed air is desirable, requiring either a number of motor-driven compressors or a central compressor with air mains. In any case there is a difficulty which has to be overcome which does not exist in the case of the diffused air system.

(10) The horse-power can be varied in proportion to the flow. Experience in connection with the chemical trade has shown that mechanical agitation requires a greater horsepower than air-lift action where agitation alone is required. Where both agitation and aëration are required, the horsepower for the diffused air method will be very much less than that required for mechanical agitation where complete dependence is placed on the atmospheric surface of the liquid for aëration. Diffused air gives not only agitation, but an enormous increase in the contact surface between the air

and liquid. It is most important to note that, during the times of greatest flow of sewage, the aëration effect can be doubled by working two air compressors instead of one. It should be noted that in such a case the horse-power will only be doubled. Experience has shown that the floor velocity is increased 50 per cent under such conditions. The extra velocity effected increases the contact between the air and water owing to the fact that the bubbles are retained for a longer time in the tank. In the case of mechanical agitation the velocity in the tanks must be doubled to double the aërating effect, on the assumption that the saturation of oxygen by the liquid exposed to the atmosphere is instantaneous; but if this assumption is not correct, the proportion will be even greater. This must increase the horse-power greatly, because it is necessary to cube the horse-power to double the velocity of flow.

(11) The concentration of all running machinery at one central point under cover with a complete stand-by plant, the easy adjustment to flow with a minimum of horse-power, the absence of causes tending to produce bad effluents all tend to lessen the cost of work and to promote efficiency in the diffused air system. The large number of machines which cannot be installed in duplicate which are exposed to the weather, and which extend over large areas, must be more liable to small breakdowns, tending to produce bad effluents; and the impossibility of adjusting the plant to varying flows and the increased cost of attendance and maintenance must make the mechanical agitation method more costly.

(12) It appears that the first cost of installation must necessarily be very much greater in the case of mechanical agitation than in that of the diffused-air method; for it is obvious that where the process depends upon aëration the intensification of the aëration will mean that the work can be done in a smaller tank, while reliance upon aëration obtained merely by contact of the liquid with the atmosphere on the surface must entail a tank or channel of very much greater length, and it does not seem possible that this can be avoided.

Undoubtedly the case of Sheffield will be quoted against these arguments. There is no suggestion that the process of mechanical agitation will not produce a good effluent under special conditions—e.g., where the sewage is weak and contains iron salts which cause precipitation and clarification. The comparison is one of relative economy under ordinary conditions.

Continuous Flow and Fill and Draw Systems.—It is necessary to make a further comparison of two methods of working—viz., that in which the sewage flows continuously through the tank and is purified in its course, and that in which a tank full of sewage is purified, after which the purified effluent is drawn off, one being called the continuous flow system and the other the fill and draw system. Both these systems have been tried, and there is no doubt that the continuous flow system in the diffused air method possesses the chief advantages. For instance, with the fill and draw system a greater tankage and a larger power plant are required. The continuous flow system is automatic in action during varying dry weather flows and during storms; simple hand stops or valves at the sewage inlet and a small number of valves on air pipes are all that is required. In the fill and draw system additional manual labor is required to operate the inlet and outlet sewage valves and also the air valves. A fixed time table for operating valves cannot be arranged owing to the constant variations in both volume and strength of sewage. At least three valves must be opened and closed in each complete cycle for each unit. Moreover, the tightness of these valves is essential in the case of the fill and draw system and is not essential in the continuous flow system. In the continuous flow system, either the pressure or the volume of the air can be varied automatically with the flow, but in the fill and draw system the supply of air is intermittent, constant attention is required to regulate the air supply during filling according to the height of the liquid in the tank, or a much greater volume of air will pass into the tank when partly full than is required. With the continuous flow system the fresh sewage flows into full tanks and thus flushes of trade waste or other inhibitory flows are greatly diluted with the partly treated sewage; but with the fill and draw system a flow of this kind occurring at the starting of the filling of a tank would destroy the activity of the sludge.

It is very important to notice that, with a constant supply of air, there is no tendency for the pores of the diffusers to choke or for an increase in the air pressure to be caused in the continuous flow system. On the other hand, intermittent working causes choking and an increased air pressure. It is true that the diffusers can be easily removed and cleaned, but the time and cost of the work must be allowed for and also the increase in horse-power due to increase in pressure before the diffusers are cleaned. This is a very great drawback to the fill and draw system. Activated sludge ought to be continuously aërated. In times of small volumes of weak sewage flow, the sludge can be concentrated in few units in the continuous flow system, and thus a great reduction in the volume of air and horse-power required can be made at night and during the average dry weather flow. Seeing that activated sludge must be continuously aërated to prevent deactivation, extra units have to be provided in the fill and draw system for storm flows which must be kept in action, and this means that a far greater horse-power is required in the case of the fill and draw tanks during the average dry weather flow and lesser flows. In the continuous flow system the activated sludge is drawn off from the bottom of the tank as settled and the effluent is drawn off at the surface, and, as there is no connection between the sludge and effluent pipes outside the tank, there is no risk of mixing sludge with the effluent, but with the fill and draw system it is extremely difficult to prevent the activated sludge being drawn off with the effluent, while instances have occurred of the whole tank being emptied of sludge by mistake at night owing to the attendant keeping the means of agitation working whilst emptying the tank. In this case also effluent draw off valves are below the surface and thus any loss of liquid through valves during agitation causes a loss of sludge and a contamination of effluent; hence the need of having the valves perfectly tight, otherwise a constant low percentage of suspended matter cannot be guaranteed without constant supervision and attention. This difficulty does not occur in the continuous flow system. The loss of head in the continuous flow system is only a few inches, and if required, in the case of the diffused air system, the effluent can easily be delivered at a level above that at the inlet sewer by means of air lifts forming part of the process. With the fill and draw system, there is a loss of head equal to the depth of the liquid drawn off. With the continuous flow system, when the sewage is more dilute in times of storm, it can be allowed to pass through the tanks at a quicker rate, and all that was necessary is to make the settlement tanks capable of dealing with the maximum storm flow. With the fill and draw system the time of filling, of quiescence, and of drawing off is constant; consequently in storm times the volume treated cannot be increased in proportion to the extra dilution. Thus extra tankage is required as compared with the continuous flow tanks.

There is one advantage in the case of the fill and draw system—viz., that it is not necessary to lift the sludge—whereas in the continuous flow system the sludge has to be passed back into the tank, and this means a certain amount of work; but the advantage is not very great, the extra horse-power required to lift the sludge being about 1 b.h.p. per million gallons of sewage treated, and the reaëration effect due to the intimate contact of air with the sludge in the lift more than compensates for the extra power required in the case of the continuous flow system. It will be observed that the bacteria in the continuous flow system are kept constantly supplied with air during the whole of the twenty-four hours in the day, but in the fill and draw system the bacteria receive no air during times of draw off and quiescence, and hence the conditions for keeping up the activity of the sludge are not so good. The working of the continuous flow system is practically automatic, while the working of the fill and draw system is dependent upon the close and constant attention of the men in charge, and there is thus great difficulty in preventing some of the sludge from mixing with the effluent and contaminating it.

Methods of Producing Aeration.—It is clearly necessary to ascertain the most effective and economical method of aëration for purification, and if the air is to be used also for the agitation of the sewage the discovery of the best method is still more important. Much work has been done in this respect.

The induced air method used by Dr. Angus Smith—viz., the rotating tube method—was tried, but as this involved moving machinery in the tank, it appeared to be open to objection. Water jets inducing air were tried, but this [illegible] bubbles so minute [illegible] were retained in the tank by the circulation of the liquid long [illegible] had been depleted [illegible] economical [illegible] involved long pipe [illegible] and water friction in the pipes, which is, of course, much greater than air friction, and this method also proved to be uneconomical. Air was induced into the rotor of a centrifugal pump; but here, again, the bubbles were too small, and the overall efficiency of this form of circulation was found to be far below that of air compressed directly and diffused at the bottom of the tank. Dropping water from a height was also tried, but the efficiency of the arrangement was found to be low. Finally, diffused air, delivered at the bottom of the tank was found to give best and most economical results. Experience proved that the best results were obtained in forcing air through some porous material, and many experiments were made with materials such as sandstone slabs, lead and leather, etc., perforated by fine needles; small glass tubes of .01 in. diameter were tried, also filtros stones. These all proved to be less satisfactory than the material discovered and used by Activated Sludge, Limited, which is of the nature of a porous concrete. The bubbles obtained are about ⅛ in. diameter and these do not coalesce to any great extent as they rise.

A great deal of work has been done in studying the diffuser in actual working, and also by making experiments in special tanks. From these experiments it seems clear that if the supply of air is continuous with a volume of not less than 14 cu .ft. per minute per square foot of dffuser surface no choking will occur. The choking only occurs where diffusers are blown intermittently, in which case even double the volume of air will be insufficient to prevent choking. Thus an allowance of from 1 to 2 cu. ft. of air per minute per square foot of diffuser is required, the volume varying with the porosity of the diffuser. It is found that the oil used in the air compressor has little or no effect on choking —in fact, it is thought to prevent growths in the pores of the diffusers. Galvanized steel pipes or coated cast-iron pipes are used for the air mains. Seeing that the diffusers show some slight difference in action, it is necessary to arrange the air pipe with a throttle valve to each diffuser; but when once this valve has been adjusted, no further attention is required. In order to reduce the number of air pipes and valves to the minimum, the diffusers are made as long as possible, and are also made as narrow as may be consistent with producing the bubbles required. In America it was for some time the practice to cement porous tiles into grooves made on the bottom of the concrete floor. This was found to be open to objection, because if a flaw developed in one of the tiles it allowed sludge to penetrate, and all the tiles in that section became sludged up, and the whole tank thrown out of action. As the result of experience, the Americans have returned to the English practice. It is extremely important that every diffuser should be arranged so that it can be easily removed and replaced without stopping the flow, and for this reason the tiles should be arranged in cast-iron boxes, the thinner the tiles the smaller the friction loss in passing the air through it. Hence, long, narrow diffusers in cast-iron boxes have been found to be the best arrangement.

Diffusers arranged at the bottom of the tank are naturally liable to be trodden on, so that it is important that these should have cast-iron frames to protect them from damage, and for the same reason that they should be as narrow as possible. The ratio of diffuser surface to tank surface was in the early days taken as being from ¼ to ⅙ of the tank area, but this has now been modified, and a ratio of not less than 1/18 has been adopted.

With regard to the most economical method of aëration, it is necessary to consider first the rate of solution of the oxygen, and next the best method of circulation in order to reduce the horse-power to the minimum, and, finally, the best form of the tank to give this circulation. The rate at which oxygen is absorbed from the air is given by Dr. Adney and Mr. Becker as S.A.P.; S. being the avidity at which the gas is absorbed, A. the total interface between the air and the liquid, and P. the partial pressure of the gas absorbed. The initial pressure of the gas in the bubble in an open tank is, of course, proportional to the depth of the bubble in the tank. Thus the rate of solution increases with the depth of the bubble in the tank, and therefore the air should be diffused at the bottom of the tank, and the deeper the tank the quicker will be the rate of solution. The diffusers are therefore best arranged at the bottom of the tank with the double purpose of giving the maximum agitation and the maximum rate of solution of oxygen.

Methods of Obtaining Circulation by Diffused Air.—There are four typical methods of obtaining circulation by diffused air. The first is the rapid horizontal circulation in an endless tank by means of air-lift pump action; an example of this is the arrangement at Worcester. The Sheffield tank used by Mr. Haworth appears to be a modification of this, with this difference—that instead of air-lift pumps, mechanically driven rotary paddles are used, aëration being effected by contact between the surface of the liquid and the atmosphere, whereas in the Worcester tank aëration is effected by the aggregate surface of the bubbles plus area of the surface of the liquid in contact with the atmosphere.

The second method of circulation is by means of a series of vertical whirlpools reaching right across channels through which sewage passes slowly, as in the case of the tank installed at Withington by the Manchester Corporation.

The third method is that of having a series of compartments, in each of which there is a vertical circulation with its axis at right angles to the direction of the flow of sewage through the tank. This arrangement was tried at Tunstall with success.

The method now generally adopted by Activated Sludge, Limited, after experience with the above three methods, is that of a spiral motion right through the length of the tank, as in the million gallon tank at Davyhulme. The rapid horizontal circulation method in an endless channel by means of air-lift pump action was worked out in connection with a fill and draw tank, although the first tank to be installed on this principle was a Worcester on continuous flow lines. The Worcester tank showed that it was an unsatisfactory method for continuous flow because partly treated sewage passed away with the more fully treated sewage, making it necessary to double the tank capacity as compared with the slow horizontal method through a series of whirlpools. With the horizontal circulation method and with the vertical whirlpool method it is necessary to have ridges in the tank in order to prevent the deposit of sludge between the rows of diffusers. This reduces the capacity of the tanks and increases the cost of construction and complicates the drainage.

Best Form of Tank.—If Dr. Fowler's idea of applying the principles of stream purification is followed it is clear that the tank should consist of a system of channels of as great a length as possible. The tank bottom should be flat in order to obtain the greatest capacity with the least cost and in order to obtain simple drainage. The circulation must be such as to produce a self-cleansing velocity across the bottom of the tank in order to prevent the deposit of the heavier matters in suspension. In order to prevent short circuiting the tank is divided up into many compartments with a small orifice connection between adjoining compartments, with diffusers on each side of the orifice, thus compelling the flow to pass through a zone of diffusion on both sides of the orifice. The wetted areas of tank walls, bottom and baffles must be a minimum, because the horsepower required for a given circulation is proportional to the wetted area. The least wetted perimeter of an open channel is where width is twice the depth. A channel with a depth of 50 per cent greater than the width has, however, a wetted perimeter only 17 per cent greater than a channel where the width is twice as great as the depth. The rate of solution of oxygen is proportional to the depth of the tank. The horse-power required to compress air is slightly less than the direct proportion to pressure. The air lift effect increases with the depth of the tank. For these reasons the depth of channel 50 per cent greater than the width has been chosen as a working rule. The circulation must be regular—that is, free from conflicting eddies—if the horsepower used is to be the minimum for a given floor velocity. It will thus be seen that the tank with a spiral motion is the only one which gives all the conditions necessary for an ideal tank.

The settlement of the activated sludge from the final effluent has presented some difficulty, but this difficulty has been overcome by the adoption of an ingenious invention, the principle of which is that the energy of inflow is destroyed in a part of the tank which is as far away as possible from the place in which concentration of sludge occurs.

From this special inlet the liquid falls with a very slight velocity by reason of which matters in suspension fall at a greater velocity to the bottom and are not disturbed by the upward current; the return or upward velocity is too slight to prevent settlement of the sludge. This section of the tank has a pyramidal bottom, the sides of which slope at an angle of 60 degrees with the horizontal.

Effluents containing suspended matters as low as two parts per 100,000 are thus obtained without difficulty.

Modern Architecture

By JOHN W. SIMPSON,

President of the Royal Institution of British Architects.

From The Surveyor, London, Nov. 5, 1920.

In determining the merit of modern architectural work there are certain actualities to be taken into account if we are to arrive at a true judgment. "New needs" form perhaps the chief reason for the change from what was deemed traditional design. Educational and commercial requirements, for example, have altered materially since our boyhood, and have to be frankly recognized and provided for.

Another and most important factor in contemporary design is hygiene. We are still boggling at soil, waste, and ventilating pipes, deliberately omitting them from our elevations, and letting the sanitary engineer carry them as he can, sprawling over our piers, cornices, and roofs, where they are not shamefully buried in the walls. But the apartments to which they pertain have perforce to be considered, and fenestration becomes a difficult matter; we may no longer plan majestic ranges of window, behind which bathrooms, sinks and sanitary needs are left to be contrived as best they may. Health authorities fix the area of our windows, settle their height with relation to the ceiling, and (very properly) take no account of a predilection for unbroken wall-space, or of a desire to build according to the tradition of our forefathers; in which, I may observe, external fire-escape stairs found no place. Inside the building similar questions arise. Staircases must be enclosed, to the destruction of delightful vistas; elevators incongruous to renaissance motives, are wanted; immense conglomerations of pipes, tubes, and wires must be laid out, and planned in shafts where they can be reached for repair; light and ventilation take precedence of suggestive mystery, and the effect on plan and decoration is revolutionary.

It is useless to cry after the traditions of past days; our problems are altered, and we have to solve them in our own way. Naturally, the change is not yet complete. Fragments of old, beloved formulæ still cling to us—not only architectural; railways have existed for a century, yet there are still in use carriages which retain the lines of a stage-coach; the motor car has long been common, and, as Wells once said, "Before each still trots the ghost of a horse."

As for "national style," whether it be good or bad, it clearly exists. No one could mistake a British city for one of any other country; our national signature is written all over it. It is, nevertheless, possible that we are on the verge of such a new departure in our art as has taken place in the art of warfare, where "fighting," in the historic sense, with development of guns and swords, seems likely to give place to mere destruction by misuse of the products of peaceful industries. In our case it may well come about by frank recognition of the qualities of the machine, as opposed to obsolete methods of hand work. There is nothing inherently uncongenial in the association of machine work with architecture; the real incongruity is in attempts to maintain, or revive, mediaeval craftsmanship in the twentieth century. Its charm lay in its spontaneity, its unaffected fitness for the surrounding of its date; to imitate it is to fabricate artificial flowers, which lack life and perfume. We live in an age of machines, and true architecture must needs reflect their influence. If we set ourselves to the planning and construction of buildings supremely proper for their purpose, art will take care of itself. An artist will always solve his problem artistically. Finding inspiration in stern utility, he transmutes it by his touch into

"Some fragment from his dream of human life,
Shaped by himself. . . . ."

Tests on High Tension Steels in Reinforced Concrete Design

By H. KEMPTON DYSON.

From Concrete and Constructional Engineering, London.

The tests described in this paper are the outcome of an agitation that has been proceeding over a period which commenced some years previous to the war. Certain firms of reinforced concrete specialists had been selling special steels which they contended could be safely stressed to considerably more than ordinary mild steel. They had employed their reinforcements in works which they had designed, where they had adopted such higher stresses, but the then proposed regulations for reinforced concrete which were being formulated by the London County Council and submitted to the Local Government Board did not permit them to use such higher working stresses. This they considered to be unfair, and they protested vigorously to the various technical societies and in the press.

The Joint Committee on Reinforced Concrete conducted by the Royal Institute of British Architects took notice of this contention in their second report and suggested that if stronger steel were used the allowable tensile stress might be taken at half the stress at the yield point of the steel, but in no case should it exceed 20,000 lb. per square inch. This, of course, should be compared with the figure of 16,000 lb. per square inch which they advocated as the working stress on mild steel, having an ultimate tensile strength of 28–32 tons per square inch.

The Concrete Institute was one of the chief bodies concerned with the criticism of the regulations of the London County Council when they were in draft. They made the most suggestions for alteration, and their suggestions were largely adopted. They supported the contention of the specialist firms interested, and agreed with what had already been advocated by the British Joint Committee, in suggesting that for special steels, such as medium carbon steel and drawn steel wire, a working stress of 20,000 lb. per square inch should be permitted.

The officials of the London County Council and the Local Government Board however, did not agree with this recommendation; and the Regulations, as finally approved, permit only of the steel being stressed to 16,000 lb. per square inch, and moreover they provide that the steel shall conform to the quality required by the British Standard Specification for steel for bridges and general building construction. This the firms interested considered to be grossly unfair by restricting proper improvement in engineering practice, and they protested to the Concrete Institute very strongly.

Eventually, as a result of the agitation, the Concrete Institute decided to appoint a special sub-committee which should report to the council and upon which all those commercially interested would be represented, together with certain professional members considered to take a somewhat independent view. The writer of this paper was appointed chairman.

After considerable discussion, it was thought best to conduct a preliminary series of experiments, which would give data that might serve as sufficient evidence to convince engineers generally, and the authorities in particular, or would serve as a basis to devise other tests, which could be witnessed by official representatives.

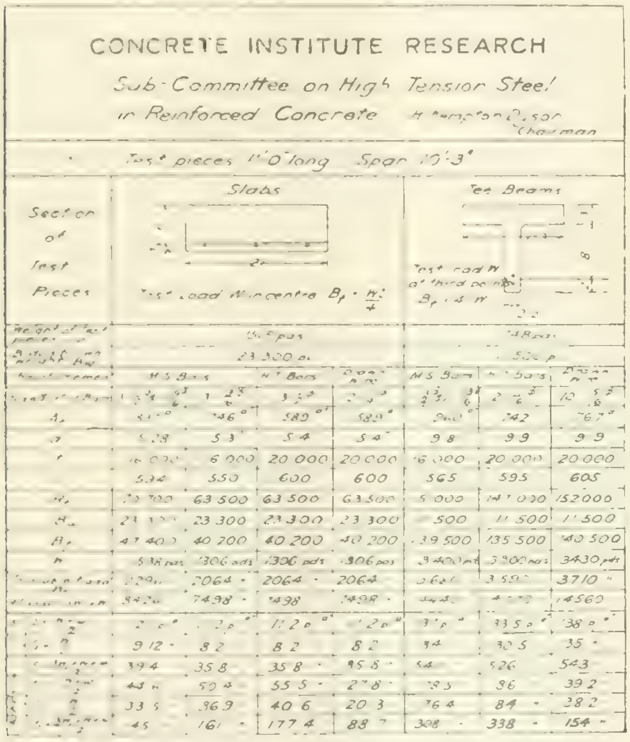
Tests on Slabs and Beams.—The discussion brought out certain opinions which it was desired to test, and two sets of experiments were considered necessary.

The first set consisted of a number of slabs which were to be tested with a point load at the centre. These tests had for their object to show whether steels of higher tensile strength than mild steel could be employed to give a greater moment of resistance than mild steel, without undue cracking by reason of the extra extension resulting from the higher stress. These tests were such as not to test the shearing resistance of concrete.

The second series of tests were on beams in which the shearing resistance of the concrete was to be tested, it being thought by some that if special steels were used, which could be stressed higher than mild steel, the size would be correspondingly reduced, and with the diminution in the size of the reinforcement, the ratio of circumference to area would be increased, so that the adhesion would be similarly greater, and that this increased adhesion might reduce cracking, and [illegible] the [illegible] to resist [illegible] tensile stresses, [illegible] greater shearing [illegible]. In particular [illegible] that where a number [illegible] steel wire [illegible] the adhesion would [illegible] greater than where only a few bars of large diameter were used, that the concrete would not be cracked adjoining the supports, because the extra adhesion would enable the concrete to be stretched without cracking (an argument originally put forward by Monsieur Considere) so that the shearing resistance might be found to be thereby increased.

Design Features of Test Pieces.—Series of slabs and T-beams were designed to meet these theoretical views. In the first series mild steel bars were disposed in the slabs to compare with the special steel reinforcement. In the first case a slab was designed so that when the stress in the steel was 16,000 lb. per square inch the stress in the concrete would be approximately 600 lb.

In the second case the area of the steel was such as would develop 16,000 lb. per square inch, while the stress in the concrete was only about 550 lb. per square inch, that is to say, the area of steel provided was approximately twenty-sixteenths of the high tensile steels, the stress in the concrete being kept below the usual working stress of 600 lb. per square inch.



CONCRETE INSTITUTE RESEARCH

Sub-Committee on High Tensior Steel
in Reinforced Concrete
[illegible] Chairman

Test pieces 11'0" long Span 10'3"

Section of Test Pieces

Slabs: Test Load W in centre $B_r = \frac{Wl}{4}$

Tee Beams: Test load W at third points B_r [illegible]

	Slabs				Tee Beams		
[illegible]	3[illegible] pds				[illegible]48 pds		
[illegible]	23 300 [illegible]				[illegible] 500 [illegible]		
[illegible]	MS Bars		HT Bars	Drawn wire	MS Bars	HT Bars	Drawn wire
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
A_s	[illegible]	[illegible]46	589	589	[illegible]	742	[illegible]67
d	5 28	5 3	5 4	5 4	9 8	9 9	9 9
f	[illegible]	6 000	20 000	20 000	[illegible] 000	20 000	20 000
	534	550	600	600	565	595	605
M	[illegible]	63 500	63 500	63 500	[illegible]5 000	14[illegible] 000	152000
B	23 [illegible]	23 300	23 300	23 300	[illegible] 500	11 500	11 500
B_r	4[illegible] 400	40 200	40 200	40 200	[illegible]39 500	135 500	140 500
W	538 pds	1306 pds	1306 pds	1306 pds	[illegible]	[illegible]	3430 pds
[illegible]	[illegible]	2064	2064	2064	[illegible]	3 59[illegible]	3710
[illegible]	[illegible]	7498	7498	7498	[illegible]	[illegible]	14560
[illegible]	[illegible]	[illegible]	112 0	[illegible]	[illegible]	335 0	[illegible]38 0
[illegible]	912	82	82	82	94	305	35
[illegible]	394	358	358	[illegible]58	54	526	543
[illegible]	43	59 4	55 5	27 8	[illegible]	86	39 2
[illegible]	33 5	36 9	40 6	20 3	[illegible]6 4	84	[illegible]8 2
[illegible]	45	161	177 4	88 7	308	338	154

Table I.—General Data in Design of Test Pieces.

The special steels on the market were found to belong to three types, namely, those of

(1) Medium carbon steel, like "Indented" bars;

(2) Cold worked steels, such as twisted bars;

and (3) Drawn steel wire.

The concrete was made in what was supposed to be the ordinary average manner, of the ordinary quality employed in buildings, for which the working stress adopted would be 600 lb. per square inch.

Table I, gives the general data regarding the design of the test pieces. It shows working stresses under working loads. It was anticipated that the tests would show a factor of safety approaching 4, that is to say, that the breaking load would be four times the working load given in the table. The loads stated in the table include the deadweight of the specimen itself.

What the Test Records Show.—The detailed records of the tests indicate that the factor of safety shown for the slabs reinforced with mild steel rods was approximately 3.6, that is to say, the moment of resistance at rupture was 3.6 times the moment of resistance for which they were designed when the stress was 16,000 lb. per square inch.

This factor of safety of just under 4 has been evidenced in numerous tests on reinforced concrete beams, and we must therefore reckon that in practice we are really content with this factor of safety.

The test records show that if we are content with the same factor of safety for high tensile steels, then it would be right to design (as compared with the working stress of 16,000 lb. for mild steel) for working stresses of 22,000 lb. per square inch for medium carbon steel and 21,500 lb. per square inch for "twisted" steel bars, and 25,000 lb. per square inch for drawn steel wire, of the respective qualities employed in these particular tests.

As regards the question of the deflections being greater, consequently the cracks larger, the tests show that the deflections were certainly greater, because, of course, the loads sustained by the beams were bigger; but the tests bring out quite clearly, as is shown by photographs, that in all cases the increased stress developed in the steel did not result in larger cracks, but only in a greater number of cracks, therefore the argument, that by using a higher stress the steel would be exposed more to corrosion falls to the ground.

As regards the tests on the T-beans, the writer thinks that these failed to show any of the supposed advantage that there might be in the smaller sizes of reinforcement. That is to say, the test results do not appear to show any increased resistance to shear even when drawn steel wire was employed. The failure occurred very nearly as was originally estimated.

Points Brought Out by the Slab Tests.—The writer would like to add, however, some personal observations of his own, for which, it must be clearly understood, the Committee accept no responsibility. He hopes that these tests may be accepted as sufficient evidence by the Societies, London County Council and the Ministry of Health, to warrant the sanction of a higher working stress for special steels without putting the firms and others interested to further expense, because these tests have meant a considerable expense, both of money and of time and they appear to be pretty conclusive.

The tests on the slabs bring out clearly certain points which have been noticed in other tests and serve to illustrate a point which the writer desires to emphasize. It has long been argued by practical exponents of reinforced concrete design that slabs, as commonly designed and constructed, are one of the strongest parts of reinforced concrete construction, and that as regards their compressive resistance, they are much stronger than theoretical calculations would indicate, that is to say that a much higher percentage of steel could be employed without failure of the concrete. Evidently, if this is so, the determination of the stresses in the concrete is in error. The primary difference is probably due to the efforts of certain academic engineer professors, who have studied the works of elasticians, and have for some decades advocated the design of beams for working stresses, such working stresses being reduced by dividing the ultimate strengths of the materials by a factor of safety, instead of following the procedure of the earlier engineers—practical men who did an enormous amount of construction and obtained their knowledge from actual experience; such older engineers experimented to find the ultimate resistance of beams and other parts of structures, and then adopted as the working load for such members a load which was obtained by dividing the ultimate resistance by the factor of safety. It is very difficult to determine what are the real stresses in the material at intermediate stages in the loading of such tests as have here been described, but the conditions at the point of ultimate failure are more readily ascertained.

The Modular Ratio Factor.—It will be familiar to all students of reinforced concrete that in the formulæ which are commonly used there is a factor introduced called modular ratio. This is supposed to be the ratio between the modulus of elasticity for the steel and the modulus of elasticity for the concrete. The tests on these materials show that the modulus of the concrete is continually changing, getting less as the stress increases, whilst the modulus for the steel drops very considerably when the yield point is passed, and with cold worked steels there is no well-defined yield point, so that there is no well-defined modulus. It is really not necessary to introduce the modular ratio into the formula at all, and it is suggested that it would be far better to abandon this mysterious variable and calculate always for probable ultimate resistances of beams, and then divide the resistance by the factor of safety, in order to obtain the working load.

All our data regarding reinforced concrete beams are derived from tests, and we know very little about what happens at intermediate stages of loading as regards the real stresses in the beams, but we know something definite about the point of failure. If we make our calculations for the ultimate resistance, we shall have to abandon the triangular stress strain distribution for the compression in the concrete and adopt some such figure as an ellipse or a parabola. Personally, the writer favors the ellipse as a nearer approach to the truth. The fact that the stresses are distributed more like the ordinary ellipse in the compression area of the beam accounts for the fact that one can put much more than the usual percentage of steel in slabs or rectangular beams without causing failure of the compression.

These tests illustrate what other tests have done, that as the load increased, the cracks at the centre crept up higher and higher, until the stress passed beyond the yield point of the steel and the steel began to extend considerably. The crack then extended so high that the portion of concrete left to carry the compression was so small that the concrete had to be ruptured. In all these tests the steel was never broken. It was the concrete which failed, and yet by estimating an approximate lever arm, one can calculate that the stress in the steel was so great that it was the steel that really was the primary cause of failure. There was plenty of concrete to enable the steel to be stressed well beyond its yield point. The fact that the bars were well hooked at the ends probably enabled the yield point to be exceeded considerably, though it has been contended by some investigators in the past, who did not properly anchor their steel, that the yield point was the critical factor and that when the yield point was reached the beam was bound to collapse. By their argument, the factor of safety in reinforced concrete was about 2 to 2½, and consequently some engineers thought that in order to ensure a proper factor of safety of 4, a working stress of about 10,000 lb. per square inch on mild steel should be adopted.

Of course the shifting of the neutral axis up towards the top of the beam is indicated by the ordinary theoretical formulæ if only we remember that when the stress in the steel passes the yield point, the modulus in the steel drops very rapidly, while if the concrete is not failing the modulus is dropping much less rapidly, the result therefore being that the modular ratio decreases; and if in the ordinary formulæ we insert a lower value for the modular ratio, the position of the neutral axis is found to be much nearer the top of the beam. It seems to the writer a matter of importance to get a method of calculation which is precise from a mathematical point of view, yet is at the same time practical. It is a subject which he hopes to deal with again in a more detailed manner.

How to Obtain Records of Snow Fall.—It is always a difficult matter to obtain a true record of the quantity of snow falling by means of the ordinary rain gauge owing to the effect of wind eddies and drift, and the result, when reduced to the equivalent water, is generally less than it should be. A more satisfactory result is obtained by exposing a flat snow board, consisting of a thin board about 12 in. square and covered with a sheet of white cotton flannel, in some convenient position on the ground where the snow does not drift. When the snow ceases to fall the rain gauge should be inverted on the board and a cylinder of snow cut out the same diameter as the gauge. This can be melted and measured in the usual way. The snow board should then be cleaned and dried, and exposed on the top of the newly fallen snow in readiness for the next fall.—From Municipal Engineering, London.

Reinforced Concrete Wheelways.—A new use for reinforced concrete is proposed by Mr. Robert Drummond, the Surveyor to the Upper District of the Renfrewshire County Council. "Horseshoes," he states, "cut the sealing coat of bituminous roads, and when the surface is broken the rubbershod wheel rapidly causes disintegration and corrugations. The problem may, however," he states, "be solved by the introduction of 'wheelways,' and experimental lengths of reinforced concrete tracks are to be laid in the Paisley and Cowglen roads, and if the scheme continues successful it may meet the difficulty of carrying mixed traffic and at the same time provide a foothold for horses."—From Municipal Engineering, London.

The Adaptation of Road Widths and Arrangements to Modern Traffic Requirements

By JOHN ALEXANDER BRODIE, M. Eng.,

City Engineer of Liverpool, President of the Institution of Civil Engineers.

Condensed from Mr. Brodie's inaugural address as president of the Institution; as printed in The Surveyor London, Nov 5, 1920.

In this country most of the larger cities originated long ago as villages or clusters of houses surrounding strong points, becoming in course of time small towns and gradually enlarging until they reached their present importance. In recent times particularly, the increase in the area and number of inhabitants of the larger centers of population has been great. It is not to be wondered at therefore that the arrangement of their streets has been, and is still found in many cases, very ill-suited for the conditions of today.

Danger of Hasty Planning.—The recent policy of the hurried erection of large numbers of cottages for the working classes, while little or nothing is being done in providing for the erection of larger houses or building of a more important appearance, is likely to have the effect of superseding the more orderly planning, and of spoiling the effect of the wider roads, where these have been adopted. The provision of satisfactory arterial roads is not in many cases being sufficiently attended to, and unless greater care is taken to safeguard main lines of communication, it will, in some cases, be difficult for residents to reach their houses in outlying areas within any reasonable time.

Lack of Central Authority.—The fact remains that neither at the center of government nor locally does there exist in this country any individual or body whose duty it is to coordinate the various separate and completely independent local authorities surrounding important town centers, so that orderly development and continuity of policy in the larger matters can be insisted upon, and no effectual means appear to exist (other than absorption of such areas by the adjoining larger authority) of inducing them to sink small local differences, and to act together in the greater interests of the trading center of which they in reality form part, or even to safeguard the greater national interests which some of them represent.

Engineer Does the Hard Work.—Waves of enthusiasm in connection with town planning and housing have done a great deal of good by directing the attention of municipal engineers, surveyors, architects, builders and others, to the various problems connected with the proper planning and development of towns, and much has been done by conferences and lectures to broaden the view of public representatives on councils and committees.

The real spadework of town development will no doubt continue to devolve on the municipal engineer, whose duty it generally is to advise from day to day and to deal with the engineering problems which lie at the root of the satisfactory planning and replanning of town areas, and who usually has the intimate knowledge of all local matters likely to affect the proper treatment of the area coming under his control.

Street Car vs. Motor Bus.—The question of improved means of local passenger service in the larger towns is one of essential importance, requiring the serious consideration of municipal engineers responsible for the provision of new streets as well as of those responsible for operating the surface-carrying systems of our great towns. Though attempts to speed-up have been made, the safety of the other users of our present narrow roads has prevented much improvement in this direction.

The introduction of the motor omnibus has in some cases resulted in a quicker service, but, unfortunately, it has been found that in actual work the cost per car-mile of operating motor omnibuses, when all charges are included, exceeds the similar cost on the overhead wire electric tramway, while the cost per seat-mile of omnibuses, as shown in published figures, exceeded the cost per seat-mile in tramcars by 114 per cent.[*]

No doubt improvements in the carrying capacity of motor 'buses may reduce the relative cost per seat-mile, but the inherent difficulty of safely steering very large motor 'buses

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[*] It is not entirely clear that interest on investment was included in the total charges on which this comparison is based, but it appears most probable that they were so included.—Editor.

[illegible] speeds in narrow and [illegible] streets will probably prevent the ordinary tramcar figures being reached, and it is probable that the tramway vehicle itself is capable of even greater relative improvement than the motor 'bus.

On the whole, it appears likely that the balance of advantage will remain with the tramway or guided type of vehicle, wherever large numbers of passengers are to be carried along a route where conditions are such as to permit of improved acceleration, high average speeds, and the best results being obtainable from both types of vehicles.

To put road passenger services on a proper footing municipal engineers and others interested will, however, have to provide roads suitable for high average speeds, while tramcar builders will have to redesign their vehicles and adopt some of the good points in motor-'bus construction, which tramcars at present lack.

Quieter, Speedier, and Better Looking Roadbeds.—Great improvements both in speed and comfort can be introduced on surface tramways in wide roads under special conditions. I may cite an instance where the rails are laid on wooden sleepers on a clinker foundation, the upper surface within the limits of the track being finished in grass, and a low fence or hedge provided on each side to keep off stray animals. Speeds up to 20 miles per hour have been authorised by the Board of Trade, and are being run safely, and tests show much higher maximum speeds, while still using the old-fashioned top-seat tramcars with a short wheel-base. With cars specially designed for quick acceleration maximum speed exceeding 30 miles per hour could be quite safely reached between stopping stations spaced approximately ¼ mile apart, and when thought necessary the introduction of a third line of track would enable non-stop cars to be introduced at rush hours on which high average speeds could be attained. Should it become necessary, the construction of express lines below the street surface is a possibility.

Whether fences can be maintained when the land on each side is fuly developed for residences and shops remains to be seen, but it is probable that the advantages of the quick and safe transit which can be so provided will outweigh the disadvantages of fencing, and in any case the fence can easily be lowered, or otherwise made to meet requirements, should such a course become necessary. At least double the mileage can be obtained on such a line from the car, the driver and the conductor, as compared with the tramway laid on the narrower street surface, and though the current consumption will be greater, the earning power and costs per passenger-mile should, on the whole, be in favor of the quicker services It is also found that the running of the cars in such a line is very much quieter than on the more rigid and paved track usually laid. On the whole, the time appears to be ripe for the introduction of radical improvements in connection with the longer-distance systems of tramway transport.

Surface vs. Subway or Elevated.—The question how far such a method of construction can be carried down through the already built-up portions of the larger towns is one which requires careful consideration.

If fast services are to be given, it will be necessary in any case to have special tracks, and experience leads me to think that in most cases an improved and widened street surface, if judiciously chosen, will be both cheaper and more advantageous to town residents and to passengers than anything in the nature of underground work, the cost of which has in the past been so heavy as to prohibit the paying of dividends on capital expenditure in any but the very large cities.

Where the total population to be carried will not warrant the necessary heavy expenditure on underground tunnels, and where overhead railways do not find favor, it is likely that a limited number of fast surface lines, constructed on wide roads through the more densely-populated districts branching out fan-like into the outer areas now being developed, could be made to compete successfully, both in time, cost of working and general convenience, with any other system at present in sight for distances of from 3 to 8 miles from the center of a city.

History of Main Roads in Towns.—The introduction of horse tramways by companies as a means of conveying local passengers, and the construction in many places of single-line and passing-places—thus causing great inconvenience to the general users of the road—directed public attention to the necessity for street widening, and the subsequent introduction of the electric system of operation induced many authorities to spend large sums of money on street widenings, though these in most cases did not exceed a total width of 60 ft., while the great increase in road traffic by motor vehicles, combined with the necessity for improved passenger communication, is again causing a demand for further improvement in road facilities.

The 120-foot Main Road.—Figures show very clearly the advantage and economy of foresight, as applied to the construction of main approach roads in the first instance.

As the result of experience, my authority has adopted 120 ft. between street fences as a standard minimum width for main arterial roads through the unbuilt outskirts, the main building line being set back 12 ft. from the fences, making a total width between buildings of 144 ft. One great advantage of providing ample width at first when land is cheap is that provision can at any time be made for express services either on the surface by additional lines, or just below the surface in cases where such an extra cost would be warranted by subsequent traffic due to increase in population.

The typical Liverpool road of 120 ft. or more in width has in the centre a double line of tramways finished with a grass surface, the rails being laid on wooden sleepers with low privet side hedges separating this track from the carriageways, which are in duplicate, one on each side for traffic entering and leaving the town respectively, each road having a width of 24 ft. between curbs, the balance of width, beyond the footpath requirement, being left in grass until additional width of carriageway is required. Streets and avenues of greater width, which allow of boulevards or exercise spaces, are at present being constructed throughout areas now being developed for housing schemes, and in other cases where the provision of width for traffic would involve the destruction of fine trees.

That the more enlightened policy in regard to wide main roads is not of isolated character is shown by the case of Birmingham, where, after the fullest inquiry, the authority adopted the prescription of property lines to a width of 120 ft. on all the main approach roads to the centre of the city, and there is no doubt that many of the larger towns will ultimately follow this bold and statesmanlike view of the future requirements as affecting the best interests of the inhabitants. Leeds, Manchester, Dundee, and other towns have also such roads under consideration, and it can be safely assumed that when authorities understand and recognize the full benefit on public health and general grounds of the lead in this matter, the policy will be more generally adopted.

Incidental Benefits of Wide Roadways.—Some engineers and other authorities, when discussing widths of roads, have been accustomed to look upon them as a means of providing for traffic requirements only, and in any view this is a serious error. As one who has had the opportunity of observing almost daily for over thirty years the use made of a roadway, somewhat exceeding 120 ft. in width, within the built-up portion of the city, I could not fail to recognize the very great value of such a space to the residents in the closely-housed areas on each side of it immediately behind the more imposing frontage residences. Especially in the evenings after business hours, and during the winter months, when parks and recreation grounds are practically unlit and therefore not available, it is largely used as a promenade and exercise ground, and it is not too much to say that no other space provided by the public authority is more appreciated and used.

A Thoroughfare Every Half Mile.—It is intended that roads of this character shall be laid out through the outer areas not yet developed at distances of approximately ½ mile apart, and with cross roads of the same class at distances of about 1 mile apart. It has been found by experience that in built-up portions of the town the main roads, carrying tramway traffic, are conveniently spaced at approximately these distances apart, and as the number of houses to the acre in the new outskirts is only one-third to one-quarter of what was the custom twenty-five years ago, while the tramway-riding habits of the people have increased during the same period sixfold, these distances appear likely to meet requirements.

Secondary Streets.—Secondary roads, averaging about 80 ft. in width, are intended, halving the distances between main streets in each direction, and in the case of the cross streets smaller secondary roads will again subdivide the areas at about ¼ mile apart.

It is intended to leave a fairly free hand in the lay-out of the internal streets in the plots bounded by main and secondary roads. No portion should much exceed a walking distance of ¼ mile from the main road with its public passenger service, and, though the tendency of present-day authorities seems to favor right-angled turns, curves, and other features, which look well on plans, it is hoped that the general direction of pedestrians travelling out of the area will be towards the intersections of the main and secondary cross roads with the main radial road, at which points stopping-places for the passenger vehicles are provided. Through traffic of all sorts will find the easiest and most direct lines of travel to be by means of main and secondary roads, leaving the residential street largely undisturbed, except by the purely internal traffic required by the residents within the area.

Under these conditions additional width in the main and secondary roads where required for through traffic can be provided without excessive cost, and it is intended to reduce the amount of land and street works to a minimum for the internal roads, and so to reduce the average cost of laying-out the whole area, while giving the width required for traffic purposes where it will be of the greatest public advantage.

Roads Outside Town Areas.—The improvement of existing roads outside town areas, and the provision of new roads to meet the requirements of increased modern traffic, have received a great deal of attention from responsible engineers who are accustomed to look ahead, but few radical improvements have been carried out in this country, and practically no typical new main roads have been constructed.

Many of our roads are too narrow to permit of motor vehicles passing bulky loads, which are so prominent a feature in many country roads. Where the more permanent road materials are being laid it is also a great advantage to be able to construct one portion of the carriageway while the remainder is used for the passage of ordinary traffic. It is probable therefore that no width of carriageway less than 30 ft. will meet the requirements where any considerable amount of traffic is to be expected, and carriageways 36 ft. in width, with ample margins and separate footpaths, should in many cases be provided.

The Set-Back Line.—The time has probably arrived when the erection of any house or building immediately abutting on the side of any main road should be prohibited by law. The question of how far buildings should be kept back is important, but, bearing in mind dust and noise, and the danger to children and domestic animals from passing traffic, the adoption of a universal building line for new erections not less than 60 ft. from the center line of main roads is to be strongly recommended. The land lying between the house and the road need not, in most cases, be added to the road, but when the house is built to the new line, such land might be made use of as gardens; alternatively, the land could be utilized for ordinary agricultural purposes until required by traffic for road widening.

Public Fences.—Another matter of considerable importance is the question of the improvement and maintenance of hedges and fences. Where additional width is necessary between fences, the Road Authority might be made responsible for the construction or planting of the new fence and for its subsequent maintenance. In this way suitably maintained road fences would ultimately become possible, to the great advantage of roads and road users, while the owners of the land would, in most cases, be glad to be relieved of this responsibility. Such a general policy, if combined with the power to purchase land for widening at the average value of the fields or other areas abutting on the road, would probably enable great improvements in the nature of straightening and widening to be carried out cheaply and quickly.

Provide for Fast Traffic.—If, with these measures, all curves were increased to a minimum radius suitable for fast traffic, and were reasonably banked up on the outer side, another great step would have been taken towards genuine road improvement.

At corners and intersections it is very necessary that sufficient open spaces, free from obstacles, should be left, with the object of enabling fast-moving vehicles to be safely manœuvred. Regulation is also required at intersections, and signs should be fixed clearly indicating which line of traffic should proceed and which should slow up.

Trunk Roads for Heavy Transport.—When dealing with roads outside built-up areas some consideration should be given to the necessity for the construction of new trunk roads in this country, and there can, I think, be little doubt that a limited number of such roads should be laid out wherever the amount of traffic is likely to warrant their construction.

The surfaces should be capable of taking all the various types of land traffic at present in use, and it would appear that one double-track railway for goods, and also a double track for an electric passenger and goods service should be provided. At least a double track for heavy motor-wagons in each direction would be required on such a route, as is shown by the large amount of traffic of this description which is at present making use of the main roads at certain times of the day, and a double track in each direction should be provided for light vehicles. The foregoing provisions would necessitate a width of at least 150 ft., and, as ample for future requirements should be provided, it is probable that 180 ft. in width between fences would be looked upon as reasonable. The ordinary cost might, under existing conditions, amount to about £200,000 per mile.

It appears to me that a very thorough reconstruction and reorganization of the road system is one of the most urgent problems of our time. The lengths of roads requiring earliest attention are probably those which are in or near the outskirts of the larger towns, where the provision of new houses on a large scale is at the present time being carried out, or where, in the ordinary course of development, lengths of improved road will be necessary, and can still be arranged for and carried out at a comparatively small expenditure before building takes place. Special attention should also be given to the neighborhood of the smaller towns through which main roads pass, where serious obstruction takes place, and where there is still the possibility of obtaining land for the construction of by-pass roads, and thus avoiding heavy expenditure on the acquisition and demolition of buildings.

Work for Veterans.—Modifications on a large scale usually require time for their completion, and involve large expenditure of public money, but it may be that in the near future work will have to be provided for large numbers of the younger and more able demobilized men who, owing to war conditions, have missed the opportunity of receiving a training in any of the usual branches of work which have been, during the war, practically at a standstill. Numbers of such men have been absorbed in the various works in connection with the provision of additional and improved housing accommodation so badly needed in many places, but it is difficult to see any class of work on which, under present conditions, men without training can be employed which is likely to be of more permanent value to the country at large than the provision of improved roads such as I have referred to, and which, in any case, would have to be carried out in the near future.

Plant of Heltzel Steel Form & Iron Co. Running Day and Night.

The plant of the Heltzel Steel Form & Iron Co., Warren, O., which was damaged by fire on June 2, started operation again on June 12 and since that time has been running day and night as in the past three months. Plans have been completed for rebuilding and the plant will be entirely under roof within the next 90 days.

Manganese in Water.—The presence of manganeses in potable water rarely causes direct trouble, as 5 milligrammes of manganese per litre, which would make the water distasteful, would be very exceptional. For paper-makers, dyers, laundries and the photographic and brewing industries manganese is very troublesome, however, and the accumulation of manganese hydrate deposits in water pipes is in any case objectionable. Some bacteria favor this deposition, whilst some algae store the manganese without forming local rust spots. In Dresden, where there was considerable trouble with manganese in the water mains, the growth of algae is hence fostered by providing filter beds of a fine porous gravel or sand, and since the adoption of these beds seven years ago, the formerly frequent complaints that the linen turned yellow have altogether ceased. (Journal für gas beleuchtung, December 25, last). The gravel itself does not retain the manganese, nor could 1.5 milligrammes of manganese be removed from Berlin water by the aid of eight cellulose-asbestos filter chambers. But when a layer of 73 cm. (3 in.) of manganese dioxide (pyrolusite) is superposed over 40 cm. of gravel, the manganese is retained; the sand grains should have diameters 1.5 mm., the pyrolusite grains diameters of about 2.5 mm. In this way a Pschovr beer brewery has been able to cure the water which was believed to spoil the yeast.—From Engineering, London, March 18, 1921.

The Rural Road Problem in England

By EDWARD JOHN [illegible]
County Surveyor, Somerset.

[illegible] Surveyor, London, [illegible]

Rural roads, both main and district, are suffering severely under present-day traffic; motor-omnibus routes are opening up in every direction, heavy and [illegible] commercial traffic is increasing, and the milk-collecting motor vehicle, having [illegible] its introduction, is being put on the country roads and lanes in increasing numbers. The pleasure traffic during the summer months is now very extensive, and seems likely to go on increasing. It appears to the author that the increase in traffic is rapidly assuming such proportions as to be the cause of very considerable anxiety in the search for a reasonable course to pursue in the immediate future.

Road Widths.—A very great deal has been written about widths of roads for the accommodation of modern traffic, and while admitting that a large proportion of what has been suggested is doubtless very desirable, it is submitted that under prevailing conditions, and notwithstanding the desirability of widening roads as a provision for future traffic developments, the widening of rural roads to 40 ft. or 60 ft. is today an impracticability. It is hoped that the consideration of this paper will result in the evolution of a practicable proposition suitable for immediate adoption. To this end the author expresses the opinion that a standard width of 18 ft. is sufficient for rural roads, with the exception that in certain cases of considerable mixed fast and slow traffic 27 ft. should be adopted in order that there may be room for three vehicles abreast, thus permitting the fast to overtake the slow. The necessities of the times call for the exercise of great discrimination in the selection of roads to be given the greater width, and it is believed that the proportion of 27-ft. roads would prove to be relatively small. An enormous improvement would be effected if roads now 14 ft. to 17 ft. wide could be widened to 18 ft. throughout.

Choice of Road Materials.—Bearing in mind that a practicable line of action is being sought, the selection of materials which will withstand the traffic presents very considerable difficulty, and it is obvious that water-bound macadam must still be used on many miles of roads for some years to come. It is not proposed to deal with concrete as a road material, since the author is of opinion that the high initial cost, the uncertainty of a sufficiently long life to justify such initial cost, and the fatal bar of construction in half-widths, puts it out of bounds for serious consideration as a part of the present problem.

The improvement of road surfaces will undoubtedly be provided by the increased use of asphaltic, bituminous, and tarred macadam, using wherever practicable local materials in order to cheapen the construction. Before such surfaces can be laid many roads will need strengthening and reshaping, probably additional drainage, and also the provision of some form of side support or kerbing—all such necessities, of course, adding to the cost.

The price of tar has reached such a figure that a greatly extended use of bitumen may be looked for, though large quantities of tar will still be required for surface treatment. Bitumen is now quoted at a lower price than tar. On such roads as traffic requirements justify its use two-coat asphalt work is probably the most suitable method, the plan being adopted of executing such a length annually on each selected road as financial considerations permit. On many roads this method would provide the requisite additional strength as well as supply a suitable surface.

There are differences of opinion as to the most satisfactory method of constructing bituminous macadam roads. It is submitted that the use of a previously coated material is preferable to the grouting method, as the latter is slower in execution, being to a certain extent dependent upon weather conditions, is less certain in its results, and permits more voids. Tarred macadam has the advantage that it can be laid some days after tarring, but bituminous mixtures must be laid while still hot. The lack of suitable plant for bituminous work, and the present expense of providing the same, will be a detriment to many authorities in the use of bituminous work. If it were practicable for the wealthy companies supplying bitumen to provide on loan suitable plants, with a competent man in charge for portions of a year, passing the plant on to various authorities, it is thought that a [illegible] difficulty [illegible] disposed of. Even if such a course were desirable, the contractors experienced in the work will not be able to carry out all the work of this character which will be required, and necessarily large quantities of it will have to be done directly by the road authorities. The continued use and extension of tarred material will depend to a large extent upon the price of tar, and the extent to which facilities for the increased use of bituminous macadam are provided.

The publication of the Ministry of Transport's designs for standard road signs should cause a very great improvement in the signposting of the country roads, though there will doubtless be numerous authorities who will consider that expenditure on this work is not an urgent necessity, and it is to be expected that in many instances action will be deferred until other forms of road work have assumed a less pressing aspect.

Finance.—The financial aspect of the problem under consideration must receive serious attention, and the question of how the moderate policy outlined above is to be financed at once obtrudes itself. In many quarters it is apparent that the high-water mark in taxing has been reached, and a strenuous campaign of economy is at present in full swing. If it is correct to say that the cost of road works is now two and a half times what it was in 1914 and the assumption is allowed that the amount raised by rate is double what it was in 1914, it is clear that less work would be done now than in 1914 if it were not for Government assistance in respect of classified roads.

The highway authority on one hand says it will not raise any more money by tax for roads than it is now doing; the motorist on the other hand, having paid the new tax will make an urgent and insistent demand for improved roads, and mechanical transport is increasing rapidly in all directions; therefore the only money available to meet increased costs and improvements is that provided by the motor tax. Will this meet the case? The Minister of Transport stated recently that the estimated number of mechanically-propelled vehicles in use was 750,000, and that this was increasing by leaps and bounds. The tax estimated to be produced from 750,000 vehicles is £9,000,000.

An actual case will illustrate the financial position in the clearest manner. In 1913-14 an authority spent £92,000 on the rural main roads. In 1920-21 the similar expenditure was £167,000. The estimates for 1921-22 are £247,000, of which £150,000 is estimated to be provided by the authority, and £97,000 by classification grants. Taking two and a half times the 1913-1914 expenditure, the result is £230,000. It is therefore evident that the sum of £17,000 is the available provision for improvements, better surfacing, and to cope with the ever-increasing traffic. It is submitted that such provision will not suffice. Apparently the only hope of further financial provision is to be found in an increased yield in the tax from motor vehicles, the number of which is "increasing by leaps and bounds"! It would be interesting to know how the additional £9,000,000 will be distributed when the number of vehicles reaches 1,500,000. Will the existing percentages contributed towards classified roads be increased to absorb it or will additional roads be classified?

The figures given above relate to main roads under a county council, and by the help of grants towards classified roads it is shown that they can barely carry on. The case of the district roads under rural district councils is much worse. It is probable that the mileage of district roads which will benefit by classification grants will be small, but the increased costs due to char-a-banc and milk-lorry traffic will be large. These increased costs if met at all must be met by rating, but if the limit in that direction has been reached, then the district roads must perforce remain in poor condition for some time at least.

It is thought that the above brief statement of the rural road case will clearly indicate the necessity for forming a correct estimate of the possibilities of great improvements in that class of road in the near future.

Conclusions.—The following conclusions are suggested for adoption as a line of action in the immediate future:

1. That the general width of rural roads should be 18 ft., with a few exceptions, which should be 27 ft.
2. That concrete is not a suitable material for rural roads, because of high initial cost, uncertainty of sufficiently long life, and the great disadvantages of construction in half-widths. (This conclusion does not apply to new roads.)
3. That it is desirable to extend the use of bituminous and

tarred macadam for road surfaces to the utmost extent of financial possibilities, selecting the more important roads for early treatment.

4. That the surface-tarring of water-bound macadam should be continued, pending conversion to bituminous macadam, and that district roads subject to mechanically-propelled traffic should be surface tarred wherever possible.

5. That the Ministry of Transport's standard road signs should be adopted forthwith, and every reasonable endeavor made to proceed with the scheme.

Stresses in Steelwork

By S. BYLANDER

From The Surveyor, London, April 8, 1921.

Through the introduction of the Steel Frame Act in London, the design for and calculations of steelwork for buildings have become with advantage, more uniform, and I feel that greater improvement still would accrue from more standardized method of design and calculation of details. It will be readily conceded that the structural elements, as compared with the main members, must be of at least equal strength, so that they may be safely relied upon to withstand the loads they and the main member have to carry, and I would suggest that while the factor of safety for the main member may be cut down for the sake of economy, it is poor policy to reduce the effective strength of the smaller parts.

My view is that connections and elements of parts of a structure may be more severely strained than the main part calculated from the assumed loads, owing to irregular alignment, contacts, and attachments. A greater safety factor must be used for details than for main members; that is, the details must be made somewhat stronger than is theoretically required, if a reliable structure is to result.

Basis Stress.—It will be found that in the majority of cases 10 kips (=10,000 lb.) per square inch is a safe unit stress for steelwork. It has therefore occurred to me that this unit of 10 kips could be adopted as a basis stress for structural steelwork, and that for varying conditions this basis stress could be multiplied by tabulated stress factors varying for pillars, beams, girders, and elements of structural details. The advantage of adopting the idea of a standard basis stress for a particular material would tend towards simplicity, as the basis stress could be varied at will, while the stress factors would remain unchanged, and by this means the engineer's requirements for the structure could be modified to suit the quality and cost of work desired and the safety factor permissible. Such variation in the basis stress would affect all the various calculations, without the necessity of specifying in detail for every one—simply by changing one figure only.

The stress factor will represent the increase or decrease of the basis stress due to—

1. Method of loading.
2. Shape and building up of the cross section and parts of structural member.
3. The mode of riveting bearings and abutting surfaces and connections.
4. Slenderness, flexure, and stresses from other causes than intentional loading.
5. Grade of workmanship, etc., and others.

The stress factor is chiefly defined by theory, and can be computed theoretically under assumptions generally accepted in engineering practice. Some must, of course, be determined rationally from engineering and mathematical reasoning.

The stress factor for a definitely stated condition, therefore, is not variable, but represents a mathematical function, while the basis stress may be varied by reason of judgment in each case. The shear stress on gross sectional area of webs for girders, and on rivets, could safely be set at 10 kips, as a standard working stress for rough calculations. A narrow riveted compression flange under ordinary conditions, riveting and slenderness, could also safely be stressed to 10 kips per square inch of the gross area. Let us now take the tensile stresses, which, when only the gross sectional area is known for built-up sections, and 20 per cent reduction is made for rivet holes, the safe stress might be set at 14 kips or 1.4 of 10 kips per square inch on the gross area, while the stress on the net area might be set at 17 kips (about 7½ tons). In exceptional cases, where no secondary stresses have to be allowed for, I would even go as high as 20 kips per square inch on the net area. This might be considered the maximum allowable actual stress from all causes. You have therefore the simple and often admitted comparison that working compression stresses on the gross area should be calculated as only half of the working tensile stresses on the net area.

For tension only, the maximum stress would be twice the standard basis stress, or the tensile stress factor would be two.

Latest Practice.—The present practice is, I think, to reduce the compression stress so that the stress at 90 radii is not more than 10, and at 120 radii, 7 kips, and further the stress factor for narrow flanges of girders to be—

$\frac{l}{d}$	Stress factor.
20	.80
30	.60
40	.40

The bearing for rivets is increased, but the bending stress is retained at 16 kips.

I believe that when flexure and other secondary stresses occur, there should be two limiting stresses specified, the lower maximum for the principal stress only, and the higher maximum total stress being for primary and secondary stresses added together.

Beams.—Engineering experience or judgment in each case is generally used at the present time by the designer, to determine the stress, and little assistance can be found in literature on the lines I have indicated. The considered judgment of experienced engineers and designers must, of course, be the final authority as to what conditions must be taken into account. It is obviously wrong to set out by law hard and fast rules for stresses, when conditions are not at the same time fully specified.

The stresses must be dependent on the quality and uniformity of the material, the quality of workmanship in the manufacture, and accuracy in fixing together the final structure. The engineer should vary the nominal stresses accordingly.

The system of basis stress and stress factors will readily permit him to do this in a systematic way.

Pillars, struts, and girder flanges in compression are similarly treated, except that the reduction in stress for a girder flange is less than for a pillar having the same slenderness ratio. This is so because the flange stress in a girder varies from zero at ends, where freely supported, to a maximum at or near the center of span, and therefore the flexure should be less.

Beam Connections.—I have analyzed the stresses which may be expected to occur in the rivets for the connection angles or the cleats at the end of a beam, or what may be termed the "beam-end connections." When one angle iron or cleat is riveted to each side of the web of a beam at the end of same for the purpose of transmitting the load of the beam by means of rivets to another beam, then eccentric stresses are introduced, and must be considered when deciding on the carrying capacity or strength of a certain connection. The usual rough method of ascertaining the strength of a connection would be to take the strength of one rivet and multiply it by the number of rivets, and the product would be assumed to represent the total load the connection could carry; but this is obviously not safe for all connections, as the actual strength of a standard beam connection may be as low as one-quarter of the above.

Riveting.—The remarks above given for pillar riveting apply also to girders. The pitch near the end should be smaller than the pitch on the center. In good work, and for conditions applicable to the usual calculations, it is, of course, necessary that the proper pitch and distance between rivet lines (set) should be properly arranged. The minimum and maximum rivet pitch for certain size of rivets and certain thickness of plates should be specified, and the placing of rivets in a girder will also, of course, have to be made suitable to transmit the flange stress. Where local loads are applied, the shear on rivet due to such load must be calculated when computing the rivet spacing for bending. The inset for rivet or the edge distance for the plate is of great importance.

I would suggest the following as suitable stresses:

Single shear—	
Rivets (shop)	12 kips
Rivets and turned bolts (field)	10 kips

[illegible]	[illegible] kips
Bearing—	
[illegible]	30 kips
[illegible]	25 kips
[illegible]	20 kips
[illegible]	16 kips

Before concluding, I would again like to refer to the advantage of using pounds in the calculations for steelwork in [illegible] tons, cwts., and lb. I take it the natural progress will be that new regulations will be prepared for London for steelwork in a similar manner as has been done for reinforced concrete, and that such regulations will be co-ordinated so that one set of regulations will be issued for different kinds of material, such as steelwork, reinforced concrete, plain concrete masonry, brickwork, and wood etc. in which the load per square foot will be given in lb. in same manner for whatever material may be used in the construction. At present the Steel Frame Act specifies the loads and stresses in tons and cwts. while the reinforced concrete regulations are more up-to-date and the unit of pound has been used. The pound is a better unit than cwt. for small loads, such as superimposed loads on floors, the weight of the floor itself, and the small additions or deductions to the total load which have to be made on account of different construction of materials used.

Opposition to New Inventions as Illustrated by the "Tank"

By COL. J. F. C. FULLER.

From the Royal Engineers' Journal, January, 1921.

Opposition to the Coach.—In 1565 it is recorded that the first coach constructed in England was built for the Earl of Rutland, but on account of the execrable condition of the roads of this period and the dangers of the highways, it was not until 1669 that systematic journeys were attempted in England and then only between Oxford and London.

Coaching was a novelty and, like every rational and profitable novelty, before or since, its progress met with strong opposition. Early in the 17th century a bill was brought before Parliament in order "to prevent the effeminacy of men riding in coaches"; and in 1671, Sir Henry Herbert, M. P., stated that "if a man were to propose to convey us regularly to Edinburgh in coaches in seven days, and bring us back in seven more, should we not vote him to Bedlam"? Nevertheless the coach for its period had come to stay, and on Oct. 13, 1712, a weekly service was instituted between London and Edinburgh. The journey was made in 13 days and the fare was £4 10s.

Opposition to the Locomotive.—In 1641, that is, 28 years before the first coaching service was instituted in England, the Marquis of Worcester, famous as the inventor of an early steam engine, went to see Solomon de Caus in the Bicetre at Paris. Marion de Lorme, who was with him when he visited this madhouse, wrote as follows:

"We were crossing the court, and I, more dead than alive with fright, kept close to my companion's side, when a frightful face appeared behind some immense bars, and a hoarse voice exclaimed: 'I am not mad! I am not mad! I have made a discovery that would enrich the country that adopted it.' 'What has he discovered?' asked our guide. 'Oh!' answered the keeper, shrugging his shoulders, 'something trifling enough; you would never guess it; it is the use of the steam of boiling water.'" Why was Solomon de Caus there? To keep his brain from mischief; he had actually suggested that carriages and ships could be propelled by steam!

In 1769, James Watt invented the first practical steam engine. He also was considered mad, but fortunately for posterity he was not locked up. In 1804 a locomotive guided by rails attained the speed of five miles an hour at Merthyr Tydvil and 10 years later George Stephenson, financed by Lord Ravensworth, to whom was applied the adage, "A fool and his money are soon parted," began work on the Killingworth Railway. He met with immediate obstruction, Lord Eldon saying, "I am sorry to find the intelligent people of the North country gone mad on the subject of railways." Stephenson was undaunted and before the Stockton and Darlington line was completed, in 1821, he said to his pupils, "Now, lads, I venture to tell you that I think you will live to see the day when railways will supersede almost all other methods of conveyance in this country—when mail-coaches will go by railway and railroads will become great highways for the king and all his subjects. The time is coming when it will be cheaper for a working man to travel on a railroad than to walk on foot."

To this the Quarterly Review incredulously exclaimed: "What can be more palpably absurd and ridiculous than the prospect held out of locomotives traveling twice as fast as stage coaches! We should as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets as trust themselves to the mercy of such a machine going at such a rate. We will back old Father Thames against the Woolwich Railway for any sum. We trust that Parliament will, in all railways it may sanction, limit the speed to 8 or 9 miles an hour, which we entirely agree with Mr. Sylvester is as great as can be ventured on with safety."

Once the locomotive began to crawl, the sluice gates of abuse were opened, and its inventor met with obstruction at every turn. A meeting of Manchester ministers denounced the railway as being "contrary" to the law of God. Lord Derby drove the railway surveyors off his land and Stephenson had to hire a prize-fighter to carry his theodolite in order to prevent it being smashed to pieces. Pamphlets were written and newspapers hired to revile his work. It was declared that the railway would prevent cows grazing, hens laying, and would cause ladies to give premature birth to children at "sight of these things going forward at the rate of four and a half miles an hour."

Parliament supported the reactionaries; birds would be killed by the smoke, foxes would become extinct, horses would be useless and oats and hay unsaleable; country inns would be ruined, boilers would burst and blow passengers sky high, and finally, the weight of the locomotive would prevent it moving.

Nevertheless Stephenson persisted and was besought by William Brougham not to talk too much about speed before the parliamentary committee which was to inquire into the question, or else he would "inevitably damn the whole thing and be himself regarded as a maniac fit for Bedlam."

The Committee of the House of Commons assembled on March 21, 1825, and the opposing counsel addressed these words to the great inventor:

"Suppose, now, one of these engines to be going along a railroad at the rate of 9 or even 10 miles an hour, and that a cow was to stray upon the line and get in the way of the engine; would not that, think you," asked the barrister, "be a very awkward circumstance?"

"Yes," replied George Stephenson, with his face in a humorous pucker, "very awkward indeed—for the coo!"

Opposition to the Tank.—Why have I told you all this? Simply in order to avoid relating to you the studied opposition which was meted out to the tank. It is right and necessary that you should realize this, for on your support, in future years, will depend the progress of mechanical warfare, which is the subject of my lecture.

In 1914 was the tank conceived; in 1915 was it built; in 1916 was it first made use of; in 1917 did it fight for its existence, and in 1918, I go so far as to say, that without its assistance we should not that year have won the war. In 1919, an experimental machine attained a speed of 20 miles an hour; and now in 1920, is it still struggling against difficulties, for prejudice to things new dies hard and vested interest is a powerful adversary.

Whatever the tank has accomplished, it is still far from perfect, it is still in the Puffing Billy stage of 1822; Puffing Billy which George Stephenson was wont to drive close by his brother's house and concerning which, when it stuck fast at a curve, he would shout out to his wife, "Hey! Jean, come oot, and gie us a shove roond the turn!" Twenty years later we read: "A few years since 94 coaches used to pass through St. Albans daily. On Saturday last the Leeds Express, formerly called the 'Sleepy Leeds,' which has been on the road upwards of a hundred years, ceased running, it being no longer a profitable speculation."

The coach was dead, the railway had come into its own, a new and stupendous world was born, and through mechanicalizing civil movement, by replacing the horse by the steam engine, civilization has advanced more rapidly during the last 80 years than she had advanced during the preceding 8,000.

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